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ABSTRACT

This report focuses on the development of general problem-solving skills which are subsumed under the general heading of metacognition: in particular, the skills of predicting, checking, monitoring, reality testing, and coordinating and controlling deliberate attempts to learn or solve problems. The report is organized in five sections: an introduction, a discussion of the term metacognition, a relatively long review of the literature (focusing particularly on results from the author's laboratory), a discussion of the types of questions being addressed in current research programs devoted to metamnemonic development, and a discussion of the cultural relativity of many of the traditional memory skills. (AA)

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Technical Report No. 47

KNOWING WHEN, WHERE, AND HOW TO REMEMBER:
A PROBLEM OF METACOGNITION

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I. Introduction

A. Another Memory Development Chapter?

We would like to begin by sympathizing with those whose initial reaction to this chapter is, "Do we really need another memory development chapter?" During the past decade research interest in the development of memory has intensified, and currently there exists a copious literature consisting of books, projected books, and review chapters too numerous to mention. More are threatened in the near future, and the task of keeping abreast of this burgeoning literature is formidable. In view of the plethora of information sources, a complete review of the literature would clearly be redundant, and this chapter is not intended to provide an overview. Rather, the concentration is focused more narrowly on the development of certain general problem-solving skills which are subsumed under the heading of metacognition. Although the focus is primarily on metamemory development, this reflects the state of the art rather than any conviction that the metacognitive skills involved in intelligent control of one's actions while memorizing are necessarily different from those involved in any other problem-solving situations, whether experimentally induced or naturally occurring.

Even within the restricted domain of metamnemonic development, this chapter is not intended as a complete review because an excellent summary already exists (Flavell & Wellman, 1977). The review section represents an idiosyncratic selection of pertinent literature centered around research findings from our own laboratory. The main emphasis is on the efficiencies and limitations of both spontaneous and induced problem-solving skills in slow-learning children.

The particular problem-solving skills selected for review are those attributed to the executive in many theories of human and machine intelligence: predicting, checking, monitoring, reality testing and coordination and control of deliberate attempts to learn or solve problems. We believe that these are the basic characteristics of thinking efficiently in a wide range of learning situations. Thinking efficiently is a good definition of intelligence, and we are interested in intellectual development. The selection of memory processes reflects the extensive literature which predates this chapter. Quite simply, we know a great deal about the normal course of mnemonic development, and we are beginning to construct a reasonable picture of the development of metamemorial awareness. Therefore, we can use this information to help us understand aberrant development. But this emphasis on traditional memory skills should not be taken as an indication of belief in a separate memory system, that is somehow independent of the general operations of the intellect. To reiterate Reitman's (1970, p.490) cogent observations,"memory behavior does not depend solely upon a memory sub-system, it reflects the activity of the human cognitive system as a whole." In fact the terms memory and metamemory are used only as a matter of convenience to identify a traditional subset of operations. The inseparability of memory from any other aspect of cognition has long been established as an article of faith of modern cognitive psychology (Bartlett, 1932; Jenkins, 1973; Neisser, 1967, 1976; Norman, 1973; Piaget & Inhelder, 1973), and it is a reflection of this bias that throughout the chapter thinking, problem solving, learning, etc. are often referred to interchangeably with remembering. Furthermore, the concentration is on the metacognitive skills of intelligence which apply to a wider range of activities than traditionally treated under the rubric "memory."

B. Organizational Scheme

Again we would like to sympathize with those whose second reaction to this chapter is "if we must endure another memory development opus, does it have to be this long?" Obviously not, but it is, and therefore we would like to provide some hints on which sections can be selected out for readers with different purposes. In Section II, we will give a very brief introduction to the term metacognition, and the reasons why we believe interest is now focused on the various "metas" of developmental cognition. Section III is a relatively long review of data gathered in our laboratory couched in a framework of the basic metacognitive skills which are emphasized in this chapter. For those not primarily interested in the details of our ongoing research program, this section can easily be skimmed without vitiating attempts to understand subsequent sections. Section IV reflects our concerns with the type of question being addressed in current research programs addressed at metamnemonic development, with particular emphasis on programs where intervention or remediation are at least implicitly of main concern. Finally, in Section V, we examine the cultural relativity of many of the traditional memory skills examined in our laboratories and legitimized in our tests and definitions of intelligence. The particular problems of the disadvantaged child are also discussed in Section V, together with the implications for future research in the area of metacognition in developmentally delayed children.

II. Metacognition: An Epiphenomenon?

We empathize with those who express confusion at the proliferation of "metas" in the current literature on developmental cognition, and indeed there has been some serious concern that "metacognition" is an epiphenomenon recently elevated and dignified with a new title, but really the stuff that the problem-solving literature has been concerned with all along. When faced with terms such as metalearning, metamemory, metaattention, metacomprehension, metalinguistics, etc., the dubious reader may wonder why the meta need be added. The addition can be defended if at all, only if it reflects a real change of emphasis--which we believe it does. Our bias is that the processes described as metacognitive are the important aspects of knowledge, that what is of major interest is knowledge about one's own cognitions rather than the cognitions themselves. Just as fever is a secondary symptom, an epiphenomenon of disease (Oxford English Dictionary), so the outcome of intelligent evaluation and control of one's own cognitive processes are secondary symptoms of the basic underlying processes of metacognition. This is not to say that conscious control of one's own activities is essential for all forms of knowing, and indeed we have concentrated elsewhere on incidental learning as a function of active interactions with a meaningful environment (Brown, 1975), but in the domain of deliberate learning and problem-solving situations, conscious executive control of the routines available to the system is the essence of intelligent activity, the underlying force which the observed routines reflect, are symptomatic of, and are epiphenomenal to.

Before proceeding with this section it would be helpful to define what is meant by metacognitive skills, and, in order to incriminate another in the proliferation of "meta" terms, we will quote John Flavell, who more than any other developmental psychologist has been responsible for the current interest in research in this area.

> Metacognition refers to one's knowledge concerning one's own cognitive processes and products or anything related to them, e.g., the learning-relevant properties of information or data. For example, I am engaging in metacognition (metamemory, metalearning, metaattention, metalanguage, or whatever) if I notice that I am having more trouble learning A than B; if it strikes me that I should double-check C before accepting it as a fact; if it occurs to me that I had better scrutinize each and every alternative in any multiple-choice type task situation before deciding which is the best one; if I sense that I had better make a note of D because I may forget it; ... (more examples) ... Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or objective. (Flavell, 1976a, p.232)

The skeptic will be pleased to note the similarity between these activities and the activities traditionally considered under the heading "study-skills"

(Brown & Smiley, 1977b; Robinson, 1941). The area of metacognition is not as new as it would appear.

Klahr (1974) raised the question of whether the distinction between knowledge and the understanding of that knowledge is a viable one.

> Should we not consider instead two forms of knowledge: a) knowledge of the thing itself; and b) knowledge of its appropriate use? Certainly one of the things I know about K is about it per se, such as how to multiply. Another thing I know is a set of appropriate conditions under which to apply that knowledge. It seems that an increase in either is an increase in my understanding of K. (Klahr, 1974, pp.295-296).

This quote illustrates the essential interdependence of the metas with their content area; this interdependence will be discussed in a later section (IV. D.). The three main points we would like to make here are that we believe the difference between knowledge and the understanding of that knowledge (in terms of appropriate use) to be a real one with great heuristic value for those interested in what develops. Educationally, the traditional distinction between knowing what and knowing how (Broudy, 1977) is still a viable one with important implications for educational practices (see Sections IV. F., IV. G., and V. D.). Second, although there is obviously an incestuous relationship between metacognitions concerning a certain process area and the processes themselves (e.g., metamemory and memory), we believe that many skills currently being studied as skills of metacognition are trans-situational, i.e., they apply to many forms of problem-solving activity. Finally, if one is interested in the "ecological validity" of the processes we select for study, the skills of metacognition do appear to have recognizable counterparts in "real-world, everyday life" situations. Checking the results of an operation against certain criteria of effectiveness, economy and common-sense reality is a metacognitive skill applicable whether the task under consideration is solving a math problem, memorizing a prose passage, following a recipe, or assembling an automobile. Self-interrogation concerning the current state of one's own knowledge during problem solving is an essential skill in a wide variety of situations, those of the laboratory, the school, or everyday life.

In summary, we believe that the isolation, however artificial, of metacognitive skills for intensive study is a viable separation which will help us focus on the similarities rather than the differences among traditional cognitive domains (Flavell, 1976b). Furthermore, as metacognition demands the ability to introspect about one's own performance, to differentiate one's own perspective from that of others, related areas of study such as social cognition, role-taking and communication become directly relevant. Furthermore, as self-evaluation of one's own performance cannot be objective, such self-interrogation must be contaminated by one's own feelings of competence, some previously separate areas of personality development are again of obvious relevance e.g., fear of failure, need for achievement, external vs. internal control, learned helplessness and level of aspiration. By concentrating on metacognitive development, not only will artificial separations between traditional cognitive domains be weakened but boundaries across various distinct areas of inquiry in developmental psychology may be questioned. This re-aligning of boundaries cannot help but be beneficial if we are seriously concerned with the developing child as a whole person rather than as the repository of certain interesting fragmentary skills in various stages of development.

III. Metamemory: A Selected Review of the Literature

Most empirical research in metacognition has centered around metamemory; knowledge concerning one's own memory abilities and strategies. The term was introduced by John Flavell (1970) who, together with his students, has provided a rich source of data concerning the development of metamemorial knowledge. An excellent review of this literature predates this chapter (Flavell & Wellman, 1977) and will not be reiterated here. In this section, therefore, we would like to introduce some recent research from our laboratory concerned with metamemorial knowledge in slow-learning children.

In addition we will focus on a general problem with the developmental research to date, that is that the particular forms of metamemory selected for study have encouraged an underestimation of the complexity of the operations involved. The primary concentration has been on isolated fragmentary introspections concerning metamemorial knowledge rather than on the complex ongoing interaction of person, task, and strategy variables (Flavell & Wellman, 1977) that are called into play during an actual attempt to deliberately retain information. The issue of the level of difficulty of the introspection required has not been examined adequately. Thus a quick perusal of the existing developmental literature might suggest that metamemorial knowledge is quite mature by third grade (see section IV. C.). We will argue that this is an illusion created by the simple types of metamemorial skills that have been examined.

Some idea of the complexity of the metacognitive abilities demandsd of the fully mature memorizer can be gleaned by considering the operations attributed to the central processor, interpreter, or executive, introduced as the overseer in many current models of memory. Being capable of performing intelligent evaluation of its own operations is an essential characteristic of the central mechanism favored by many current theories; some form of self-awareness, or explicit knowledge of its own workings is critical for any efficient problem-solving system (Becker, 1975; Bobrow, 1975; Bobrow & Norman, 1975). The basic requirements of such an executive demonstrate the complexity of the issue. It must include the ability to (a) predict the system's capacity limitations, (b) be aware of its repertoire of heuristic routines and their appropriate domain of utility, (c) identify and characterize the problem at hand, (d) plan and schedule appropriate problem-solving strategies, (e) monitor and supervise the effectiveness of those routines it calls into service, and (f) dynamically evaluate these operations in the face of success or failure so that termination of strategic activitess can be strategically timed. These forms of executive decision-making are perhaps the crux of efficient problem-solving because the use of an appropriate piece of knowledge, or routine to obtain that knowledge, at the right time and in the right place is the essence of intelligence.

Obviously whether knowledge of his own memory or problem-solving processes will be attributed to a child will depend on the level of complexity of the judgement required. For example, the seemingly mature understanding displayed by third graders in metamemory studies to date is not apparent if more complex coordination and predictions are examined (Brown, 1977a; Brown & DeLoache, 1977; Butterfield & Belmont, 1977). In the following selected review we have attempted to consider the current literature in the light of the degree of complexity of the judgement required.

A. Secondary Ignorance: On Not Knowing When or What You Know

A very basic form of self-awareness involved in all memory and problem-solving tasks is the realization that there is a problem, of knowing what you know and what you do not know (Brown, 1975). We are indebted to Joan Sieber (Sieber, 1968) for bringing the problem of "secondary ignorance" to our attention even though it took some time before we appreciated the importance of the observation. Sieber used the term for that state beyond ignorance when one is unaware that one is in a state of ignorance. An astute observation by Holt in his book How Children Fail illustrates this situation well.

> Part of being a good student is learning to be aware of one's own mind and the degree of one's own understanding. The good student may be one who often says that he does not understand, simply because he keeps a constant check on his understanding. The poor student who does not, so to speak, watch himself trying to understand, does not know most of the time whether he understands or not. Thus the problem is not to get students to ask us what they don't know; the problem is to make them aware of the difference between what they know and what they don't. (Holt, 1964, pp. 28-29)

1. Metacomprehension. The problem of ascertaining the state of one's own ignorance or enlightenment is one of metacomprehension. Understanding instructions would be a case of comprehension of a message, while knowing that one has understood, or not, would be an example of metacomprehension. Holt's (1964) lucid description of children's mystification over school problems includes many instances of metacomprehension failures. For example, one child faced with the task of listing verbs that end with a p, became upset repeating "I don't get it" but was totally unable to say why she failed to understand. Holt then asked the child if she knew what a verb was and gave her some examples. Relieved, the child went to work. Holt believes that this child did not ask what a verb was simply because:

> She did not know herself that she did not know. All she knew was that she had been told to start doing something and she didn't know what to do. She was wholly incapable of analyzing the instructions, finding out what part of them made sense and what did not, where her knowledge ended and her ignorance began. (Holt, 1964, p.145)

Although Holt's charming book contains many anecdotes concerning the child's difficulty in evaluating his own state of knowledge, controlled experimental tests of this developmentally related phenomena are rare. In a recent series of experiments, Markman (1977) examined the insensitivity of young children to their own failure to comprehend. Children from grades 1 through 3 were asked to help the experimenter to design instructions for new games (e.g., card games) to be taught to other children of their age. The instructions were obviously incomplete and the measure of whether the child realized he had not understood was his request for more information. For example, the experimenter and the child each received four alphabet cards and the child was given these instructions. "We each put our cards in a pile. We both turn over the top card in our pile. We look at cards to see who has the special card. Then we turn over the next card in our pile to see who has the special card this time. In the end the person with the most cards wins the game." No mention was made of what the special card could be. Not only did the younger children require many additional prompts before they indicated incomprehension but it appeared that they needed to repeat the instructions or even to attempt to execute the task before they became aware that they did not know how to play the game. Since the ability to monitor one's own understanding of instructions and messages, whether spoken or written, is an essential prerequisite for all problem-solving activity, further research on this topic would be welcomed.

2. The lack of knowledge inference. Although it would seem that being aware of what it is you know or do not know is a primitive precursor of more complex forms of metacomprehension, the difficulty of this introspection is an important issue, for, under certain conditions even college students may have problems estimating the state of their own knowledge. Identifying what you do not know, or could not know can involve quite complex forms of reasoning. The mature problem-solver not only has a reasonable estimate of the accessibility of his known facts, he is also cognizant of which facts cannot be known and which can be deduced on the basis of what he already knows. Adults realize immediately that they cannot know Charles Dickens' phone number (Norman, 1973), but they arrive at this conclusion by inferential

reasoning concerning other aspects of their knowledge. Not only do children know less than adults, and often have poorly organized, incomplete and inconsistent, knowledge but they lack the complex systems of inferential reasoning used by adults to infer information from incomplete and contradictory knowledge bases. Collins (1977) has shown that college students use a variety of inferential reasoning strategies to assess the probability that an assumption is true given the information they already have. The full flavor of Collins' work cannot be given here but the types of inferences described are many and we would like to refer the reader to the protocols from his Socratic dialogues as particularly rich examples of the complexity of such skills.

3. The expert. The problems of metacomprehension can range from the awareness that one is not understanding to the strategic monitoring of awareness in order to ascertain that one has the optimal information for attacking a particular task. Consider the problem of a deliberate memorization task. The memorizer must recognize this class of problems and realize that they call for suitable actions on his part. Merely identifying the class of problems requiring deliberate remembering can pose a considerable burden on the metacognitive powers of the very young. How then would an expert memorizer go about the task of identifying the problems involved in a specific memorization task?

> No self-respecting memory expert would put up with the way psychologists run most memory experiments. Experts would ask questions like, "What must I remember?" "How many items?" "How much time will there be?" "What's the nature of the tests?" They would know what they needed to know in order to perform optimally and they would settle for nothing less. (Bransford, Nitsch, & Franks, 1977, p.)

Binet's pioneer work with "lightning calculators," "outstanding mnemonists," and chess players (Binet, 1894; Reeves, 1965) also illustrates that the expert not only needs to identify fully all the facets of a problem before proceeding but also prefers to structure the input in an optimal manner to achieve efficiency. Identifying the exact nature of a problem can be a complex act.

Thus, the task of deliberate memorization may involve complex metacognitive introspection which can tax even college students' ingenuity (Brown & Smiley, 1977b) but let us return to our embryonic expert, the preoperational child. What evidence do we have that the child knows anything about what he knows concerning even "simple" memory tasks? One method of obtaining this information is to ask the child how sure he is that his answers are correct, i.e., obtain confidence ratings.

4. Confidence. A feature of many memory paradigms is that it is possible to ascertain how confident the subject is that his response is correct. Thus, in continuous recognition memory paradigms one can consider the hit rate (items correctly recognized) in comparison to the false alarm rate (items incorrectly recognized). A conservative response bias refers to the case where the subject has a very low false alarm rate; if he designates an item as one seen before (old) it was seen before. Young children have a very conservative response bias (Brown & Campione, 1972; Brown & Scott, 1971) suggesting that they reserve their identification of old to items they are sure they have seen before. This is a very crude measure of confidence and d' measures have typically been introduced to separate out retention-based components of recognition performance from criterion or decision-based components. Using a d' measure, Perlmutter and Myers (1974) and Berch (1975) also concluded that very young children employ a conservative response bias in recognition performance. Alternatively, it is possible to approach the problem directly and require the subject to rate the confidence of his response of "old" or "new" with respect to a specific scale. Berch and Evans (1973) used this procedure successfully with children as young

as six years. Although nine-year-olds were better then six-year-olds at gauging the accuracy of their recognition performance even younger children were capable of assessing the accuracy of their response to some extent. The lower the child's level of confidence in judging an item as old, the lower the probability that the item actually was old.

The feeling-of-knowing experience in children will be considered fully in the next section, however, one interesting factor concerning confidence ratings emerged in a study by Brown and Lawton (1977). Educable retarded children, whether or not they could predict their feeling of knowing prior to a recognition choice, were able to assess the accuracy of their response after it had been made. Accuracy of recognition attributed to "sure" and "not sure" judgements are given in Table 1. The difference between categories is lower for the younger group but even here it is reliable.

Insert Table 1 about here

This difference between predicting potential accuracy prior to performance, and confidence in accuracy following performance, was also reported by Moynahan (1976). First and third graders were given eight-item lists to learn. Following recall attempts they were asked to indicate how many items they had recalled. A similar study was conducted in our laboratory with educable retarded children. All subjects were almost errorless when estimating how many items they had recalled although children of this age are unable to predict their span prior to recall attempts (Brown, Campione, & Murphy, 1977). In addition, the educable children in our study were asked to indicate which specific items were recalled. Again the children were virtually errorless at the task correctly identifying .95 of their recalled items. Apparently, even young children can gauge accurately the success of their prior recognition accuracy and recall performance. They know when and what they know if the situation is a relatively straightforward recognition memory task.

B. Prediction

The ability to accurately assess performance after a response is made contrasts sharply with the ability to predict accuracy prior to a retrieval attempt. Moynahan (1976) and Brown and Lawton (1977) attribute the greater difficulty of prediction to the degree of abstraction involved. Predicting in advance of responding requires the ability to imagine cognitive acts that have not yet occurred. There is considerable evidence that such acts of imagination are more difficult for the young child.

1. The feeling of knowing. Consider first the feeling-of-knowing experience. As with the lack-of-knowledge inference (Collins et al., 1975) it is necessary to distinguish between the recognition that a gap in knowledge exists and the active strategic attempts that might be instigated to fill "the gap that is intensely active" (James, 1890). This type of active attempt at retrieval has been considered in tip-of-the-tongue experiments (Brown & McNeil, 1966; Yarmey, 1973). For adults the tip-of-the-tongue phenomenon consists of a "feeling of knowing" (Blake, 1973; Hart, 1967) that sought-after information is known and merely awaits the appropriate accessing; followed by active strategic attempts to facilitate retrieval of the temporarily inaccessible but putatively available material (Tulving & Pearlstone, 1966).

Brown and Lawton (1977) conducted two studies on the feeling-of-knowing experience in educable retarded children of varying levels of cognitive ability (MA 6-10). The first study was similar to the paradigm used with adults. Children were pretrained to bet one to three tokens that they would recognize a familiar picture that they had failed to recall. Because a large proportion of data children recalled accurately only the younger subjects could be examined for feeling of knowing. In addition to a large drop-out rate due to accuracy, the data from a considerable number of the remaining children were suspect as they appeared to use the betting procedure inappropriately. These children wagered three items on almost all the tests and were always correct. Subsequent interrogation revealed that they deliberately "failed" to recall so that they could enjoy the excitement of the betting procedure. Furthermore, several of them were unaware that if they recalled correctly they were sure of three chips and would always get at least as many if not more from a correct recall. It was their impression that if they bet three and won three they had somehow gained six. The suspected data were not included in the subsequent analysis, leaving only 13 MA 6 children and 14 MA 8 children of an original pool of 67 subjects.

Considering only the "acceptable" data the conditional probabilities of a correct recall given that the subject bet one, two, or three chips are presented in Figure 1. Older children did recall more when they wagered more. Younger children did not appear to differentiate between a bet of one or two chips, but their probability of correct recognition given a bet of three, P(C/3) was high, indicating some feeling-of-knowing sensitivity in the younger children.

Insert Figure 1 about here

The problem experienced with the betting procedure and the high recall success rate of the older children led to an unacceptable large drop-out rate and interpretation of these results must be tempered with caution. For these reasons the first experiment was replicated, using as measures of prediction something less attractive than the betting procedure. Three groups of educable retarded children, MA 6 (N = 17), MA 8 (N = 15), and MA 10 (N = 27), were shown a pool of 100 pictures of famous characters, and asked to give the correct names. Any picture a child could not name was recorded and used in his feeling-of-knowing test. On each feeling-of-knowing trial the subject viewed a character he had not named previously and was asked to indicate whether he would recognize the name (yes response), would not recognize the name (no response) or might recognize the name (maybe response). After this, four names were read: the correct name, a totally impossible name and two names from the same category as the target. For example, if Richard Nixon were the target, the three distractors would be John Kennedy, Abraham Lincoln and Ronnie McDonald.

The conditional probabilities of a correct response given that the subject predicted he would, P(C/yes), would not, P(C/no), or might, P(C/maybe), recognize the name, are presented in Figure 1 together with the data from the first experiment. The youngest group did not predict their subsequent ability to recognize the name, but both the MA 8 and MA 10 groups did identify more items when they predicted they would be able to recognize them.

Consideration of the data from both experiments indicates a developmental trend in the ability to predict recognition accuracy when recall fails. The point of confusion lies in the estimation of the sensitivity of the youngest children. In the first experiment they did show some ability to predict their recognition accuracy for they were reliably better on those trials where they bet three items. In the second experiment however, the more representative sample of younger children did not recognize more items when they predicted that they would recognize the names. This cross-experimental difference illustrates the problem with assessing a child's metamemorial ability within only one task, a more accurate picture of his capabilities might be gleaned from considering his performance across a variety of tasks and situations (see Section IV. E. and V. A.).

2. Span-estimation. Another form of prediction which has received considerable attention is the ability of young children to estimate (predict) their own memory capabilities. Flavell, Friedrichs, and Hoyt (1970) asked children from second and

fourth grades, together with nursery and kindergarten children, to estimate their recall span. From one to ten pictures were exposed incrementally and the child's task was to indicate at each list length whether he could still recall a list that large. Whereas only a few of the older children predicted they could recall all ten pictures, over half the nursery and kindergarten children predicted in this manner. If we take estimation of ± 2 of the actual span as a measure of realistic estimation, the group means met this criterion at the second and fourth grade level but this was not true for the younger children.

Markman (1973) and Yussen and Levy (1975) replicated these findings as did Brown et al. (1977) with educable retarded children. All three studies included a training component which we will consider later (section IV. F.). Of interest here is a problem encountered in the Brown et al. study; instead of halting the proceedings when the subject indicated a list length was beyond his span, they continued to expose items incrementally until all ten had been exposed. This minor change in procedure resulted in three groups of subjects: those judged realistic (±2 of span) and unrealistic as in previous studies and a third group (32%) called inconsistent. These children indicated that a particular list length was too difficult for them but then proceeded to estimate that at least one longer list was within their capacity. Allowing subjects to demonstrate inconsistent responding markedly changed the pattern of results obtained; and there is no way of knowing how many "realistic" subjects in the previous studies would have produced inconsistent patterns of responses if given the opportunity. For example, 80% of the MA 6 inconsistent subjects in our study would have been judged realistic if we had stopped at their first "too difficult" response, the procedure used previously (Flavell et al., 1970; Markman, 1973). Of the total population, this would have led to an estimation of 28% of MA 6 subjects judged realistic, a figure not unlike those found by Markman and Flavell et al. (.22 and .36 for kindergartners). This finding illustrates a problem with accepting a young child's verbal response as a true estimate of his metamemorial capabilities, a difficulty we will also return to later (section IV. E.).

3. Estimating task difficulty. Several sources of information are available concerning the young child's awareness of task difficulty. We will consider first the questionnaire data provided by Kreutzer, Leonard and Flavell (1975). Kreutzer et al. asked children many questions about the state of their knowledge concerning the memory processes of themselves and others. We used the same questions (slightly modified) with educable retarded children as a measure of the general effectiveness of two years of consistent training in metamemory tasks (experienced vs. naive subjects). We will return to the training aspect later (section III. E.) but will include the retarded children's data here when appropriate. We selected three of the Kreutzer et al. items as particularly good tests of the child's awareness of task difficulty: the story-list problem, the opposite-arbitrary item and the rote-paraphrase question.

The story-list problem was designed to test whether children had any knowledge of the beneficial effects of embedding a series of to-be-remembered items within a narrative context. The data are presented in Table 2. There was a marked developmental difference in the type of response given by normal children. Only 50% of kindergarten children realized the greater ease of the embedded condition but all third graders were aware of this fact. In addition, 70% of the older children gave adequate justification of their choice but only 15% of the younger ones did.

Insert Table 2 about here

The opposite-arbitrary item is another example of predicting task difficulty. Here children were asked to judge the relative difficulty of learning a list of words consisting of randomly paired items or lists of pairs based on common associates (opposites). These data are presented in Table 3. The younger normal children had difficulty predicting accurately but by third grade almost perfect prediction was

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Insert Table 3 about here

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obtained. Only half the MA 8 children could preditt accurately. A consideration of justifications given for a choice further illustrates the younger child's difficulty for only a few normal kindergartners, and MA 6 retardates, could give a reasonable justification.

The third question selected was the rote-paraphrase item. Kreutzer et al.'s scoring and tabulation of this item was extremely complex and we have selected only certain salient features for inspection. The children were asked questions concerning the ease of learning a recorded story to see whether they understood the differential study and recall requirements of gist vs. verbatim recall. A summary of the main results is given in Table 4. A model child was observed asking the experimenter, whether or not recall was to be in her own words, or just like in the story. All experimental subjects were then asked the following questions - Question 1 was "Why do you think she asked that question?" The number of responses indicating awareness of the greater difficulty of verbatim recall are shown in column 1 of Table 4. Question 2 was "Would it help her to know the answer?" Yes responses are given in column 2. Questions 3 and 4 basically required the child to indicate what he would do if told to learn word for word or to acquire the gist. Any answers indicating appropriate activity are entered in columns 3 and 4. In questions 5 and 6 the child was asked which would be easier, gist or verbatim recall. Answers indicating that recall in one's own words would be easier are given in column 5 and adequate justifications in column 6. The predictions were somewhat more difficult than in the previous two items, however, the same trends are apparent. The majority of the children indicated that it would be easier to recall in one's own words, however, the majority of younger normal and educable retarded children could not justify their response, nor could they indicate appropriate study activities for each recall demand.

Insert Table 4 about here

These questionnaire data indicate that children become more aware of task difficulty as they mature. Although normal eight-year-olds are quite sensitive to the problems of task difficulty examined here, progress is not so dramatic for educable children. Of interest is that both groups are easily misled in this game, for 60% of normal six-year-olds and 55% of normal eight-year-olds believed colored pictures to be easier to learn than black and white items. This misconception was shared by the educable children, 70% of MA 6 and 55% of MA 8 children were similarly misled.

The efficiency with which children can judge task difficulty obviously depends on the type of task they must jduge. In the questionnaire study almost all the retarded children realized that recognition was an easier task than recall, while almost no child had any appreciation of retroactive interference. Again this points to the interaction of awareness and the level of difficulty of the judgement to be made. Young children are not simply aware or unaware of task difficulty. Some types of problems are readily apparent to them while others are completely beyond their comprehension.

This effect of the complexity of the task judgement is revealed in empirical studies as well as in the questionnaire data. First, consider studies on estimating the difficulty of lists of items to be rote learned. Tenney (1975) asked kindergarten, third and sixth graders to compose lists of words which would be easy for them to recall. Organizational strategies were assessed by comparing lists designed for recall with free association lists. The younger children made up essentially the same lists under both conditions, but the older subjects tended to provide category organization.

As part of our longitudinal studies of metamemory in educable children, we replicated the Tenney study with MA 6 and MA 8 children together with children from regular classes, matched for CA and MA with the educable sample. As in the Tenney study children produced units which contained four items, the key word and the subject-produced three words that they judged to be easy to recall with that key word. Details of the types of structures built into the units are given in Table 5. The three classes

Insert Table 5 about here

of organization that occurred often enough to score were taxonomic category, thematic category (i.e., grouping together objects around a theme: baby, crib, rattle, diaper) and rhymes and sound-alikes. All other responses appeared to be random. Within the normal population the incidence of random responding decreased with age as did sound responding, and there was a corresponding increase in categorization. Educable children did not improve with increasing MA and also produced many random units. Of interest is the high incidence of thematic responding. Although Denney and Ziobrowski (1972) found that young children clustered more by thematic than taxonomic category, Tenney (1975) did not find significant thematic responding in any of her groups. If we consider the proportion of all classified responses (omitting random responses) there was a high incidence of thematic responding in all groups (normal subjects, CA 6 = .51, CA 8 = .26, and CA 10 = .31, educable subjects, MA 6 = .36, MA 8 = .30). The thematic responding accounts for half of all categories used by the normal kindergarten children; all other groups used this type of response for approximately one-third of the units that are organized.

Another measure, adapted from Tenney, which illustrates the child's understanding of the task, is whether the categories that are produced are broad or narrow. A narrow category is one in which the internal organization of the unit can serve as an additional retrieval cue. For example, Monday, Saturday, Thursday, Tuesday, would be a taxonomic broad response while Monday, Tuesday, Wednesday, Thursday would be a taxonomic narrow response. Obviously, narrow responses (like 1, 2, 3, 4) are much better examples of an easy list, and therefore, we looked at the proportion of categorical responses classified as broad or narrow. These data are given in Table 6. Again the developmental trend is apparent. The number of narrow categories increases as the CA of the normal

Insert Table 6 about here

children increases. Educable children also show a slight improvement but perform more like normal kindergarten children than any other normal group. This developmental pattern is rendered clearer if one considers the proportion of all responses that are narrow categories, the most strategic form of responses. For normal children the range is .27, .75, and .80 for CA 6, 8, and 10; for educable children it is .21 and .33 for MA 6 and 8 respectively. The large majority of normal ten-year-olds "catch on" and give narrow categories as lists while this efficient response type is much less frequent in developmentally less mature individuals.

Other studies which have considered the child's estimation of task difficulty have been those of Moynahan (1973) and Salatas and Flavell (1976) where children were asked whether categorized or noncategorized lists would be easier to recall. These studies will be considered in a subsequent section concerned with the relationship between prediction and performance (section IV. D.). Here it is [illegible]fficient to point out that a similar developmental trend was found. Younger children had more difficulty than older children but almost perfect prediction was shown by third grade. Retarded children perform like normal kindergarten children (Brown et al., 1977).

We would like to describe one further study in this section (Brown & Smiley, 1977a) because it illustrates that the developmental trend in task prediction is apparent at a much later age if more complex materials are used. The procedure was based on a study by Johnson (1970) who devised an objective method for dividing prose passages into idea units. After the passages had been so divided, independent raters judged the importance of the units to the story theme. Subsequently it was found that recall scores of further independent samples of college students were determined by the rated importance of the units. The Johnson procedure is particularly suitable for use with children as it provides both a method of quantifying what is recalled from prose passages and a measure of metacomprehension. For not only is it possible to ascertain whether children's recall is similar in pattern to adults; but it is also possible to see whether the child has sufficient knowledge of text materials to determine what are the important units.

Students between 8 and 18 years were given folk tales to rate or recall. All stories rated and recalled had previously been rated for importance units by independent groups of college students. The procedure for 12- and 18-year-olds was similar to that used by Johnson with adults. The subjects were seen in groups and first listened to a tape recording of the story as they simultaneously read the passage through. The stories were printed with one (previously identified) idea unit on each line. After a second reading the subjects were told that the individual units differed in their importance to the whole story and some of the less important units could be eliminated without destroying the main theme of the story. They were instructed to eliminate N units (approximately ¼) which they judged to be the least important by crossing them through with a blue pencil. They were then requested to eliminate the next N (¼) by crossing them with a green pencil. Finally they were asked to remove a further N (¼) items by crossing through with a red pencil, thus leaving a quarter of the original units exposed. This procedure resulted in four levels of judged importance with the items eliminated first (the least important) given a rated importance score of 1 and those left exposed at the end (most important) given a score of 4. The procedure for young subjects was essentially the same except they were seen individually and received considerable pretraining in the rating procedure (for details see Brown & Smiley, 1977a).

The mean importance ratings of the four experimental groups were compared with the previously acquired college students' rated importance. These data are presented in Table 7. A strong developmental trend was apparent with a gradual improvement in the sensitivity to degree of rated importance emerging over the entire age range studied. Only 18-year-olds reliably distinguished all four levels of importance, for 12-year-olds did not differentiate the two intermediate levels of importance. The

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Insert Table 7 about here

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greater range of mean scores across the four importance levels shown by the 18-year-olds also suggests that sensitivity to fine degrees of importance continues to be refined in the high school years. Eight-year-olds made no distinction between levels of importance in their ratings and even 10-year-old students could only distinguish the highest level of importance from all other levels. Thus, there was considerable agreement between independent groups of college students and even 12-year-olds concerning the importance of constituent idea units of a text passage but eight- and ten-year-old subjects were unable to differentiate units in terms of their relative importance to the text.

All children recalled passages as well as rated them. The recall scores for all ages were extremely sensitive to the importance level of the units as rated by adults. These data are also presented in Table 7. Although older subjects recalled more than younger children, the general pattern of results was consistent across the age range of 8 to 18 years, the least important units were recalled less frequently than all other units and the most important units were most often recalled. We have some additional pilot data which suggest that this effect of structural importance is also found with much younger children. A group of 37 nursery school children and 20 kindergartners were also given the same stories to recall under a variety of conditions which need not concern us here (Brown, 1976a). Although we had considerable difficulty extracting satisfactory recall protocols, and the total number of units recalled was small, we did find the same pattern of sensitivity to structural importance as rated by college students. Considering the 32 protocols where at least 15% of the units were recalled, the mean number of units recalled was .12, .08, .22, and .42 for the four levels of structural importance. The differences between levels 2 and 3 and levels 3 and 4 were reliable. Again, there is some evidence that the least important units (levels 1 and 2) are seldom, if ever, recalled while the most important units dominate recall attempts. Our data are consistent with those reported by Yendovitskaya (1971) and Christie and Schumacher (1975); even preschool children favor the central theme when recounting stories and disregard minor nonessential details.

Thus, although children's recall does reflect an adult pattern in that important units are recalled more readily than unimportant items, young children are unable to predict in advance the importance of units of text material. This suggests that the same problems experienced by six-to eight-year-olds in predicting item difficulty in list learning tasks would also be experienced by eight- to 12-year-olds in predicting unit difficulty in learning from texts. Children who have difficulty determining the key points of a passage would hardly be expected to strategically select them for intensive study (Brown & Smiley, 1977b).

4. Predicting the outcome of strategic activity. In the previous section we examined the child's understanding of task difficulty. Here we are concerned with his appreciation of strategic intervention in memory tasks, his own or that of another memorizer. The Kreutzer et al. questionnaire contained an item that we judged a good example of the child's ability to predict the outcome of strategy usage, the study-time item. The children were given 20 colored pictures and told that two children had already seen the pictures and been asked to learn them. One child studied for five minutes; the other for one minute. The children were asked to predict which child remembered more and to justify their answer. They were further asked to indicate how long they personally would study, one or five minutes. The data from both normal and retarded children are given in Table 8. The majority of all children predicted that

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Insert Table 8 about here

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studying for five minutes would be a better strategy but younger normal children and educable retarded children were less able to justify their choice. In addition the MA 6 children did not always indicate that they would study for five minutes themselves, even if they indicated the longer time to be beneficial.

In a study currently underway in our laboratory, (Brown, Campione, Barclay, Lawton, & Jones, work in progress) we are investigating the ability of normal and retarded children to appreciate the utility of strategy usage during study for free recall. Children are asked to view a video tape of a 12-year-old child performing four different study activities, while attempting to learn a 12-item list of pictures. The four activities modelled are categorizing, rehearsing, labelling and looking. After the child views the four activities he is asked to indicate which one will lead to better performance. The entire prediction procedure is repeated to obtain reliability scores. Following the second prediction the child is himself given the same stack of pictures and told to study them in any way he wishes in order to learn as many as possible.

The prediction data for those subjects showing a consistent preference for an activity are presented in Table 9. Fourteen normal nursery school children, 11 MA 6 and 6 MA 8 educable children were not considered as they were inconsistent in their prediction. Consider first the educable retarded children. Both the MA 6 and MA 8 groups predict that the two appropriate strategies, categorization and rehearsal will lead to better performance. No child predicts that labelling or looking strategies are appropriate. The normal four-year-olds, however, are relatively evenly (randomly) divided across all four activities in their predictions. Whereas the MA 6 to 8 retardates appreciate the value of an active strategy the young CA 4 children do not. But by third grade the majority of normal children predict that an active strategy is the best activity to adopt for the purposes of remembering.

Insert Table 9 about here

Although we will consider the relationship between performance and prediction in a later section, the actual performance of children following the prediction task will be included here for closure. The data were collapsed across the two "appropriate" strategies, categorization and rehearsal. Of interest were the proportion of subjects who predicted that an active strategy would be superior and those who adopted one of those strategies themselves. These data are presented in Table 10. Although the

Insert Table 10 about here

ability of the educable children to predict the superiority of active strategies was impressive, their actual performance was less so. All educable children predicted that categorization or rehearsal would lead to better performance, yet, when faced with the identical task and stimuli, immediately after viewing the tape, only 28% actually adopted one of the activities predicted to be superior. In terms of actual performance the educable children did not differ from normal preschool or first-grade children. Third graders tend to adopt the strategy they predict would be superior, but even for these children the relationship between prediction and performance is not perfect. We are currently obtaining data from a fifth-grade sample. Initial inspection of these data indicates that even the fifth grade child does not routinely adopt the active strategy that he predicts to be superior.

C. Planning

The child's ability to plan ahead and his knowledge about the efficiency of such planning are part of his repository of metamemorial information. This knowledge has been examined both by questionnaire survey and in experimental situations. We will consider the questionnaire material first.

1. Questionnaire data. Several of the Kreutzer et al. items were addressed directly to the question of planning ahead in memorization situations. We have selected two items as particularly appropriate, the immediate-delayed items, and the study-plan item. In the immediate-delayed item, children were asked whether, after having been told their friend's phone number, they would prefer to phone right away or get a drink of water first. They were then asked what they did when they had to remember a phone number. A summary of the replies is given in Table 11. By third

Insert Table 11 about here

grade 95% of normal children indicated that they would phone first, or demonstrated that they were aware of the problems entailed by waiting; only 40% of kindergartners showed similar awareness. Educable children performed somewhere in between these two levels. Many children indicated that they would write down the phone number if they were required to remember it. All of the third graders gave some evidence of planfulness but 40% of kindergartners did not. Generally it appears that many of the educable children and the normal kindergartners could not indicate a plan for remembering.

The study-plan item was designed to test the child's awareness of strategies for studying a list of categorized pictures. In Table 12 the child's chosen activities have been divided into strategy responses and no strategy responses. If a child indicated he would employ either categorization, association, rehearsal, or external storage, this was designated a strategy response. A no strategy response was scored if the subject indicated that he would look at, or randomly rearrange the items or would do nothing at all. Normal children outperformed retardates. Again, by third grade almost all children indicated a planful behavior on this task.

Insert Table 12 about here

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2. The differentiation hypothesis. Planning for future recall can involve simple behaviors that fall within the competency of the preschool child but such planning can also involve complex coordinated patterns of strategic activity. Consider first a simple form of planning within the confines of a typical memorization paradigm. Can the young child differentiate between situations where he must actively attempt to remember and those where memorization is not required? Early studies concerned with this differentiation hypothesis suggested that it was not until first grade that children behaved differently when instructed to remember vs. just to look at pictures (Appel, Cooper, McCarrell, Sims-Knight, Yussen, & Flavell, 1972). However, the task used confounded the child's lack of knowledge of how to remember in such situations

with his awareness of memorization demands per se. If the only measure of active intervention is some indication of a strategy, not yet in the child's repertoire, it is difficult to imagine how one could expect the child to demonstrate awareness of the meaning of instructions to remember. Although the child may be perfectly aware of the difference between remembering and looking, if he does not know how to rehearse, categorize, etc., in a study period he cannot be expected to outperform children not required to memorize.

Subsequent studies confirmed this diagnosis for when just looking longer was taken as a measure of differentiation, children as young as four and a half behaved differently under remember instruction (Yussen, 1974). However, even looking time measures are sensitive to the complexity of the metamemorial judgement involved. Rogoff, Newcombe, and Kagan (1974) told 4-, 6-, and 8-year-old children that they would be tested for recognition of a series of 40 pictures after a delay of a few minutes, one, or seven days. Only eight-year-olds adjusted their inspection time according to the anticipated length of delay while the younger children did not exhibit this sign of planfulness.

If the task is sufficiently simple, however, evidence of planful behavior can be seen in children as young as three years old. Wellman, Ritter, and Flavell (1975) investigated a very simple memory situation which did not depend on the possession of skills of rote-memorization as did the Appel et al. study. Nursery-school children watched an experimenter hide a toy under one of a series of identical cups. Before leaving the room for 45 seconds the experimenter told half the children to "wait here with the toy" and the remaining children were told to "remember where the toy is." Children asked to remember the location exhibited deliberate attempts to retain the information, such as touching the correct box or making it distinctive in some way. One delightful example of "visual rehearsal" was a little girl who sequentially pointed to the cups and shook her head negatively to all non-baited cups and nodded affirmatively to the baited cup. The remember group recalled the location better than the wait group; note the children were three years old.

In situations which do not require rote recall but retention of spatial location, young children do have some concept of what it means to remember (Acredolo, Pick & Olsen, 1975). Identifying the location of objects is a meaningful task even for toddlers (Huttenlocher, 1976), but rote recalling a list of items is not usually a common task encountered by the child before the onset of formal schooling (Brown, 1975). It is hardly surprising, therefore, that the child cannot benefit from instructions to remember when he lacks the prerequisite skill to set deliberate memorization routines into motion. This series of studies provides a cautionary example of the problem of diagnosing lack of awareness from one specific situation. Whether or not a subject, child or adult, will be attributed with metacognitive insights will be determined by the level of difficulty of the task and the match between the task demands and the subjects extant cognitive skills (Brown & DeLoache, 1977; Chi, 1977).

3. Study-time apportionment. Faced with the common task of attempting to commit to memory a set of material when time limitations or other restrictions impede leisurely study, how do we plan our time for most efficient results? The task can involve very fine degrees of metamemorial judgement as any student can attest (Brown & Smiley, 1977b). A relatively simple experimental analogue was introduced by Masur, McIntyre, and Flavell (1973). First- and third-grade children, together with college subjects were given a multi-trial free-recall task. On all trials but the first the subjects were allowed to select for further study only half of the total set of items. Strategic behavior was thought to be selection of those items which had previously not been recalled. Masur et al. found that both third grade and college students did select previously missed items for extra study but this was not true of first-grade children who appeared to select randomly. The authors concluded that "the strategy of deliberately concentrating one's study activities on the less well mastered segments of materials to be learned, like other elementary memory strategies (e.g., rote rehearsal) cannot automatically be assumed to be part of a young child's repertoire of

learning techniques" (Masur et al., 1973, p. 237).

One interesting feature of the Masur et al. study was the relationship between adoption of an identified "good" strategy and efficient learning. Although the relationship between strategy usage and performance was reasonably clear for the college sample, the utility of the strategy was not so clear for third graders, and even less clear for the youngest children. First graders seem to benefit equally from selecting recalled items or from selecting missed items, the supposedly optimal strategy. Even the third graders appear to gain only slightly by selecting the missed items. One explanation of this lack of relationship between strategic selection and good performance lies in the demands of the study situation. In order to perform efficiently the subject would need to (a) identify the missed items---Masur et al. have shown that this is not a difficult task even for young children, (b) select these items for additional study, and (c) while studying the previously missed items, keep alive the previously recalled items, presumably by rehearsal. We suspect that the problem lies in (c). While the young child may recognize the missed items, and may even be aware that he should select them for more intensive study, the strategy would only be effective if he could also keep alive the nonselected, previously recalled items. Without rehearsal, known to be difficult at first grade and less than optimal by third grade, this third demand of the task would be impossible, thus mitigating any positive effects of strategic selection.

Brown and Campione (1977a) attempted to replicate the Masur et al. study with educable retarded children. The main feature of the study was its training feature where several strategies were examined. Of interest here is the pretest data. No group of subjects showed above chance strategic selection of missed items; however, when individual subject's data were considered, approximately one-third of all children selected previously missed items, however, this selection was not accompanied by an improvement in recall accuracy. Thus the pretest data essentially confirm the pattern found with young normal children (Masur et al., 1973). The majority of educable children do not select strategically, and even those that do concentrate on previously missed items do not benefit from this foresight.

Strategic study-time apportionment can involve tasks other than rote learning a list of unrelated items. Of particular interest educationally is learning from texts. Although we are beginning to identify effective strategies used for comprehending and remembering prose by adults (Anderson & Biddle, 1975; Frase, 1975) we know little about the development of these abilities in children (Brown 1977b; Brown & Smiley, 1977b). We know even less about the self-awareness needed for efficient control of such comprehension strategies. It is by no means certain that spontaneous use of a general class of mathemagenic skills (Rothkopf, 1972; Smiley, 1974) for enhancing recall is a reliable feature of study behavior even in high school and college students who have not been specifically trained in their use. Yet it is a common educational practice to instruct children to make outlines of study materials and concentrate on the main events to the exclusion of nonessential material. As we have seen, children have difficulty isolating the main events of complex prose passages (Brown & Smiley, 1977a; 1977b; Smiley, Oakley, Worthen, Campione, & Brown, 1977); thus they would not find such instructions overly informative (Brown, 1977b).

D. Checking and Monitoring

In the sections on prediction and planning we were particularly concerned with the child's ability to consider certain task-relevant aspects prior to attempting to solve a problem. In this section we will look at the ability to check and monitor the outcome of an attempt to learn or remember. As in previous sections,many of our examples come from the problem-solving literature as there are few examples of checking and monitoring in memory tasks. In considering material for inclusion here we were again struck by the prevalence of this "metacognitive problem" over a wide age range; for it is not that young children are bad and adults good at checking the adequacy of their performance, but that inadequate checking will be manifested at any age if the subject does not fully comprehend the nature of the task.

1. Internal consistency. One example of inadequate checking is the child's apparent willingness to live with contradictory answers. Examples of internal inconsistency are numerous within the literature on Piagetian conservation tasks and it has been suggested that one measure of true conservation is the child's awareness that the correct answer can be checked in many ways and that the results of all such checks must agree (Schaeffer, Eggleston, & Scott, 1974). Yet young children are less disturbed by their own contradictions than are more mature problem solvers. Consider this example from one of our studies on sequence reconstruction (Brown, 1976b). Children were asked to reconstruct a previously seen picture sequence corresponding to a narrative story. They were required to select four pictures from a possible eight. Four of the pictures had been part of the original story. Two of the distractors were obviously incorrect and the remaining two pictures were consistent with the sequence of events but had not actually occurred as part of the original. Of the preschool children who could attempt the task, 41% selected all six possible pictures and sequenced them correctly. They refused to indicate which of the six pictures they had seen themselves. A typical dialogue was as follows. Experimenter: "Which pictures of the story did you see?" Subject: "These ones" (indicating the six items of their reconstructed story). Experimenter: "How many are there?" Subject, counting: "Six." Experimenter: "How many did you see?" Subject: "Four." Experimenter: "So which ones did you see--pick the four." Subject: "I see all of them." These young children were not at all discomforted by their incompatible answers. By kindergarten, this pattern of results had disappeared.

Although we have evidence that children as young as second grade do check their answers for internal consistency, and, for example, will not accept meaningfully inconsistent sentences as part of the same story (Thieman & Brown, 1976) there are certain situations where inconsistencies will be accepted. Apparently school arithmetic problems provide just such situations as the number of examples given by Holt (1964) would confirm. Consider the following example. Two fifth graders were given the problem 256 + 327 and together with the teacher worked through each step and arrived at the correct answer of 583. Then with this sum in clear view, the teacher wrote the next problem 256 + 328 on the board and pointed out that in both cases they were adding something to 256; "instead of adding 327 we are going to add 328" hoping that the children would recognize that the answer would need to be one larger. No luck, the children laboriously worked the problem out from scratch. The teacher wrote a new problem and went through it step by step until the children were satisfied it was correct. Then, right beside it, he wrote exactly the same problem. The children again worked through the problem from scratch and came up with the wrong answer. On the board now, side by side, were two problems and their answers, 245 + 179 = 424, and 245 + 179 = 524. The children were quite satisfied with these solutions, and sure both were correct, even though, on the basis of internal consistency alone, they must reject one solution.

2. Reality testing. Holt makes a strong case that children do not expect mathematics to "make sense" and therefore it is not surprising that they often fail to employ another valuable checking devise, reality testing, or an "error-noticing, nonsense-eliminating device." Indeed, several of Holt's fifth graders were characterized as pathologically deficient in this regard. Holt describes one child as "emotionally as well as intellectually incapable of checking her work, of comparing her ideas against reality, of making any kind of judgement about the value of her thoughts" (Holt, 1964, p.48). That Holt's more striking examples come from elementary mathematics classes might not surprise the college teacher of elementary statistics faced with comparable symbol-shock symptoms in apparently intelligent adults. College students are by no means free of prejudice against reality testing, negative probabilities or variances are readily accepted as solutions if the student believes the formula was followed correctly!

If children do not realize that a subject, particularly mathematics, is supposed to make sense, checking answers on the basis of common sense must be ruled out.

Consider the following fifth grader.

> One boy, quite a good student, was working on the problem "If you have 6 jugs, and you want to put 2/3 of a pint of lemonade into each jug, how much lemonade will you need?" His answer was 18 pints. I [Holt] said "How much in each jug?" "Two-thirds of a pint." I said, "Is that more or less than a pint?" "Less." I said, "How many jugs are there?" "Six." I said, "But that doesn't make any sense." He shrugged his shoulders and said, "Well that's the way the system worked out." (Holt, 1964, p.181)

How does the general notion of reality testing apply to the realm of the problem? Although there are few examples of reality testing in the memory literature this is not because the problem does not exist but because it has not been examined. Yet the general notion of checking a procedure against common sense criteria is as applicable to memory tasks as to any other form of problem solving. When applying a memorization strategy, is the child capable of evaluating the appropriate nature of the routine he is using by asking such questions as "Does it make sense to use (e.g., rehearsal)?" "Does it pay off in terms of the type of recall needed?" "Is the amount of effort required reasonable?" Studies concerned with the child's awareness of memory routines, not as overlearned recipes for performing, but as valuable tools for thinking, are badly needed.

3. Blind rule following. The next set of examples are also taken from the literature dealing with mathematical problem solving in children. In all cases the materials used are variants of those designed especially to provide a concrete means of checking solutions, operations, etc. Holt used cuisinaire materials, briefly these consist of rods of one cm. wide and one cm. high that vary in length from 1 cm. to 10 cm. Each size is of a consistent color. All color-length correspondences are overlearned by first grade children who later use the materials to aid them in mastering increasingly complex operations---or do they?

Consider Edward, one of Holt's fifth graders who has learned a rule for counting. Edward was given 15 10-cm. rods and 1 4-cm. rod and asked how many single units he would need to make that many. (The answer is 154) First he lined up the 10-cm. rods and put the 4-cm. rod on the end. Then be began to count the rows, reciting 10, 20, 30, etc. until he reached 100, where he proceeded to touch the remaining six rods, reciting 200, 300, 400, 500, 600, 604--with 604 as his solution. Asked to try again, he realized that something must be wrong and the second time he proceeded correctly to 100 as before and then began reciting, 101, 102, 103, 104, 105, 109--with a solution of 109. Remember all 15 10-cm. rods are exactly the same height and color and Edward has been using them for years. Intervention was tried and the material was split into two sections, the first containing 100 (the first 10 10-cm. rods) and the second containing 54 (the last five 10-cm. rods and the 4-cm. rod). Now Edward could answer correctly, with no hesitation. The two sections were then pushed together in front of him and Edward was asked the original question. He proceeded through the original routine and again came up with 604. Edward is consistent at least.

Another training device was then introduced. Edward was given 100 (10 10-cm. rods) and asked how many there were, an over-learned task readily complied with. Then separate white units (singles) were added, one at a time and Edward correctly counted 101, 102, 103, up to 109, as each unit was placed on top if the last. However, when the last unit was placed on top so that there were exactly 11 rows of 10 units, Edward replied 200. What was Edward's problem? He had learned to change the unit of counting when a turning point was reached, but not why or how to change. He had certainly not learned that the task was meant to make sense.

The origins of this blind rule learning were easily seen in first graders beginning to use the rods. Each child had learned the name and color of the rods from one to ten and was beginning to use the rods for computation; they could count to 100 and deal with concepts such as tens and units etc. Although they could perform such operations in set situations, Holt demonstrated that they did not understand the basic principles underlying the rods. He asked first graders "If we started at the edge of the desk, how far across would a row of 38 whites (ones) reach?" One child immediately took out three orange rods (tens) and a brown rod (eight) and lined them up.

All the remaining children tried to line up 38 separate white units, usually losing count several times in the process. This is a fine example of the arbitrary use of the labels for the child, who, while perfectly capable of rote learning that the orange rod is a ten, does not grasp that it is in every way equivalent to ten white units. "Six is just the name that the dark green rod happens to have, it has nothing to do with its size in relation to some other rod" (Holt, 1964, p. 131).

Resnick and Glaser (1976) also report a striking example of blind rule following. Children from five to six years of age were taught to use blocks for finding the area of a rectangle. Then they were asked to find the area of a parellelogram. This is a version of Wertheimer's parallelogram problem and the correct solution is to remove the area to the left of a perpendicular, dropped from the top angle to the base, and move it over to the right side of the figure thus creating a rectangle. Resnick and Glaser found little evidence of such creative solutions. Of more interest to this section, they found quite dramatic examples of checking failures. Many children tried to apply the well-learned rule and attempted to superimpose the blocks onto the parellelogram, ignoring the absence of right angles. Thus blocks were hanging over the edges. The children proceeded as if there were no difficulty at all (Resnick & Glaser, 1976).

Holt has argued that training children on rules or recipes for problem solutions, without at the same time making them aware of the rationale behind the rule, leads directly to blind problem solving routines like Edward's. A case could be made that such an outcome could very well follow attempts to inculcate deliberate memorization strategies. It has been suggested (Brown, 1975) that there is a danger that facility with a strategy of rote learning might blind the child to possibilities of higher level interactions with the to-be-remembered material. For example, if a child is trained to rote rehearse series of digits such as 4 9 2 6 1 8, 9 1 7 3 4 2, he may attempt to rehearse the set 2 3 4 5 6 7 embedded within such a series, failing to realize that rehearsal is not needed for such a meaningful set. The analogy here is to problem solving tasks such as the Luchins's water jar problem (Luchins, 1942) where facility with a successful complex solution, applied over a series of problems, leads the subject to adopt the complex rule even when a far simpler solution could be used. Thus, subjects trained to rote rehearse may also be less likely to notice and use redundancies (Spitz, 1973) in digit sets (such as 425, 425) than subjects not pretrained in the rehearsal strategy.

We have some evidence of blind rule following in a memory task, but it is indirect and coming from the less mature children in a study of recall readiness (Brown & Barclay, 1976). Educable retarded children were trained on a recall readiness task similar to that introduced by Flavell et al. (1970). On each trial the child was presented with a list of pictures (1½ times his span) and required to continue studying the items until he was sure he can remember all of them in order. One-third of the children were trained to rehearse cumulatively, one-third to anticipate the next item and the remainder served as a control group, instructed merely to label, an activity which does not require self-testing. The success and limitations of the training will be considered later. Of interest here is the behavior of the younger (MA 6) children. Training on a specific self-testing strategy was sufficient to lead to long-term improvement in their strategy production, children trained to rehearse continued to do so, but this did not lead to a concomitant improvement in their ability to monitor. Two weeks after training the younger children were rehearsing or anticipating as trained, but this did not lead to perfect recall (or even near perfect recall), the measure of adequate monitoring of a mnemonic activity. Our explanation for the outcome is that the children were following the "blind-rule" procedure. Told to rehearse, they rehearsed, but the reason why such an activity would help them meet the recall-readiness task demands was not apparent to them.

4. Insight. Insight, the opposite of blind rule following, has traditionally been a major concern for psychologists interested in problem solving and intervention (Resnick & Glaser, 1976). Evidence of insightful solutions in young children's

problem solving is rather rare and, awkward as it may be for educationalists, such solutions often occur when children have not been taught a rule. Holt's examples of fifth-grade arithmetic problem solving situations are largely negative. There appeared to be only three compelling examples of insight among them, the one first grader who used the 10 and 8 rods to measure her desk and the following examples: Faced with the problem 2/4 + 3/5 one child immediately said that the answer must be one or more. "You need two more fifths to make 1, and 2/4 is more than 2/5 so the answer is bigger than 1" (Holt, 1964, p. 114). Similarly, another child realized immediately that ½ + 1/3 = 3/4 was incorrect "No, 1/3 isn't the same as 1/4. It took me (Holt) a second or two to see what she meant. Since ½ + ¼ = 3/4, ½ + 1/3 cannot equal 3/4" (Holt, 1964, p. 113).

We know of only two experimental illustrations of intelligent use of a memory rule by children but this is also an area where little attention has focused. In the Brown and Barclay (1976) recall-readiness task just described, the older children (MA 8) did show intelligent use of the trained strategy. Taught to anticipate or rehearse they not only maintained the trained strategy but their ability to judge their recall readiness also improved dramatically. These data are presented in Figure 2. Note that the older subjects in both the rehearsal and anticipation groups dramatically improved their performance; an improvement which was maintained for at least one year after training. This example provides some indirect evidence of intelligent rule use as the children were not explicitly instructed in how to use the strategy to ensure that recall readiness was achieved. Merely training in a task-appropriate self-testing routine was sufficient. The decision to continue using that activity until the task demands had been met was entirely the child's responsibility.

Insert Figure 2 about here

A more direct example of intelligent strategy use has been provided by Butterfield and Belmont (1977) who were concerned primarily with changes in the employment of a strategy as a function of task difficulty. That is, they were concerned with the flexibility with which an initial choice of a strategy could be made and the efficiency with which individuals abandoned a strategy when it was no longer necessary and subsequently reinstated it when its use again became appropriate. The basic procedure consisted of presenting a number of different lists of items for recall and observing the amount of time required for selection of a stable rehearsal strategy. Then, without warning, one list is re-presented for a number of successive trials, at which time an individual no longer needs to work actively on the items. Finally, new lists are introduced unannounced, and the individual must again begin using his chosen strategy to deal with the information. Younger children, as compared with older children and adults, take longer to: (a) select a strategy initially, (b) abandon it when it is no longer necessary, and (c) reinstate it when its use is again required.

The Butterfield and Belmont studies (1977) provide nice examples of the increasing intelligence and flexibility that adults come to use when applying even a simple rote learning skill. As far as we know there are few such experimental examples of intelligent strategy use in the literature; most of the existing examples are anecdotal accounts such as our report of college students' rapid abandonment of inappropriate strategies in a judgement of recency task (Brown, 1973a). What is needed in this area is systematic research concerned with when and where children will apply a strategy, and whether this is influenced by training. In addition we know of no examples where intelligent choice between two or more competing strategies has been examined, surely a more realistic analogue of real-life memorization situations.

Another neglected research area is the creative modification a subject might make applying a well-learned strategy to a new task. Although the difficulty in working with such problems is appreicated, we are surprised at the lack of research interest on such topics. One interesting avenue that could be profitable was suggested by Bransford et al. (1977). Obtaining protocols from expert memorizers might shed light on the operations they employ in order to learn. Such insights concerning efficient performance could then be used to guide instructions of the less advanced memorizer.

E. Training Studies

Although considerable ingenuity and effort has been expended in attempts to inculcate specific memory strategies in those who would not think to use them unaided, the notion of training metamemorial awareness is a new departure. With the exception of a study by Markman (1973), all major training attempts directed at the child's self-consciousness as a memorizer have been conducted in our laboratory and have been directed at an educable retarded population (IQ = 60-75). Anyone who has read the preceding sections will be aware by now that these children have a great deal of difficulty coping with even simple tests of metamemory. One explanation of their relative passivity in memorization tasks could be that this is the direct result of their lack of awareness concerning themselves as agents in the learning process. Thus, some of the main reasons for initiating the series of training studies was to see whether (a) metamemory could be improved in educable children, (b) any improvement would be durable and generalizable, and (c) any improvement would lead to a concomitant improvement in the general use of strategies for remembering.

The general rationale for such training studies with slow learning children follows from a controversy concerning the utility of training specific mnemonics in order to effect any worthwhile or lasting improvement in memorization skills (Brown, 1974; Butterfield, Wambold, & Belmont, 1973). The problem lies in the dubious success so far achieved by attempts to train common memory skills. The general picture to emerge is that educable mentally retarded children readily respond to appropriate training and evidence a variety of trained mnemonic skills accompanied by a satisfying improvement in recall performance (Belmont & Butterfield, 1971; Borkowski & Wanschura, 1974; Brown, Campione, Bray, & Wilcox, 1973). Furthermore, it appears that following well-designed and extensive training, maintenance of the effects of this experience can be detected over a reasonable time period (Brown, Campione, & Murphy, 1974).

Unfortunately, evidence for generalization to new situations is hard to find (Brown, 1974; Campione & Brown, 1974, 1977). The problem of generalization is not a new one, particularly in the context of training retarded individuals. Both American and Soviet psycholosists have suggested that one of the main difficulties in training mildly retarded children is that they tend to acquire information which is "welded" to the form in which it was acquired (Shif, 1969). A spate of recent studies has provided impressive experimental documentation concerning this problem of generalization following training (Brown & Campione, 1977b; Campione & Brown, 1977).

The lack of convincing evidence of broad generalization of a trained mnemonic strategy indicates a poor prognosis for obtaining educational benefits from such exercises and has led some investigators (Brown, 1974; Butterfield et al., 1973; Butterfield & Belmont, 1977) to advance the view that training efforts should be directed at general determinants of performance rather than specific skills or strategies. Rather than training only one domain-specific heuristic, they suggest that it would be more profitable to direct training attempts at the development of knowledge concerning strategies in general. If we are interested in effecting improvement in the child's general performance on a variety of similar tasks, then we must consider both the specific gains from training (strategy use) and the general benefits (improved knowledge concerning memory tasks).

To examine this point we have conducted a series of training studies concerned with metamemorial knowledge in retarded children. As is the case with any training study, whether directed at specific strategies or knowledge concerning memory in general, the effectiveness of training must be considered against two criteria which we have called maintenance and generalization (Brown, 1974; Campione & Brown, 1977). As a first index of successful training it is obvicusly desirable to show that what has been trained can be detected after a reasonable time period has elapsed. This is particularly necessary as there is considerable evidence that the developmentally young tend to abandon a trained behavior when no longer specifically instructed to continue

(Brown 1974, Flavell, 1970). The second, and more important, index of successful training is that of generalization to new situations; for without evidence of breadth of transfer the practical utility of any training program must be called into question (Brown, 1974; Brown & Campione, 1977b; Brown & DeLoache, in press).

1. Maintenance.

(a) Recall readiness. In the initial training study conducted in our laboratory (Brown & Barclay, 1976) recall-readiness estimations were examined, the main results of this training procedure were described in the preceding section.
In brief, educable children were trained in one of two self-testing strategies, rehearsal or anticipation, or were assigned to a control group instructed to label the items, a procedure which does not require self-testing. Following training four posttests were given, a prompted posttest (one day after training) on which individuals were instructed to continue the trained strategy, and three unprompted posttests given one day, approximately two weeks, and approximately one year later. The main results are shown in Figure 2, which gives the percentage of correct recall. As can be seen, both the younger and older children in the Anticipation and Rehearsal groups performed significantly better on the prompted posttest (posttest 1) than on the pretest. Additionally, in the Anticipation and Rehearsal groups, 13 of 18 younger subjects recalled perfectly on at least one trial, compared with 0 of 18 on the pretest; the corresponding figures for the older subjects are 24 of 26 on posttest 1 compared with 2 of 26 on the pretest. Thus, training the useful self-testing strategies resulted in both enhanced performance (percent recall data) and improved monitoring (data on number of perfect recalls). Note that the labelling group (control) did not show this improvement.

The MA 6 and MA 8 groups differed considerably on the last three (unprompted) posttests. For the younger group, performance on posttests 2, 3, and 4 was not significantly different from the pretraining level, whereas for the older group, performance on all posttests differed significantly from the pretraining level. Thus, as in previous studies concerned with direct training of a strategy, training facilitated performance, with the effect being somewhat durable for the older children but transitory for the younger ones.

The younger child's dependency on continual prompting was particularly well illustrated on the one-year follow-up tests, which consisted of four days of testing. On the two initial days, the children were given unprompted posttests identical to the previous unprompted tests. These are the data included in Figure 2. On the third day, the experimenter reverted to the prompting procedure, demonstrating and reminding the child of his trained strategy and urging its continued use. The fourth day of the one-year follow-up was a further unprompted posttest. These data are included in Table 13. Note that both the younger and older children benefit from the prompting although the effect is less dramatic for the older children who were performing quite adequately without the prompts. Of main interest is the failure of the younger children to maintain their enhanced performance on the final nonprompted test. Without continual prompting, the younger children show little evidence of the effects of intensive training.

Insert Table 13 about here

(b) Study-time apportionment. In our next training study we considered strategic study-time apportionment (Brown & Campione, 1977a). The pretest data from this study has been discussed previously (section III. C.). During pretesting, on each trial but the first, of a multi-trial free-recall procedure, educable retarded subjects were allowed to select half (6/12) of the to-be-remembered items to see if they would strategically select missed items for extra study. Following pretesting, subjects were divided into three groups for training where the experimenter selected study items for the children. For the first group of children (standard strategy) the experimenter's selection followed the strategy diagnosed as mature (Masur et al., 1973), that is, she returned to the child those items he had missed on his prior free-recall attempt.

Another type of systematic selection was adopted for the second group. Here the experimenter returned to the subject the items he had recalled plus one new item (creeping strategy). The rationale behind this was that if immature subjects cannot benefit from additional study time on missed items because they fail to keep previously recalled items alive, then the utility of the standard strategy for them is dubious. The creeping strategy would enable them to add just one extra item per trial, while permitting them to continue to review the previously recalled items. Thus they would gradually creep up to a better level of performance. The third group of subjects received randomly selected items for review on each study trial. Following training, the children received posttests where they were again free (as on the pretest) to select whichever items they wished for study, with the restriction that they must not choose more than six.

Both the mean proportion correct and the standardized selection scores (for details see Brown & Campione, 1977a), were considered on the pre- and posttests. Consider first the recall scores. The mean proportion correct recall on the pre- and posttests are presented in Figure 3. There appears to be no change between pre- and posttests as a function of any training condition for the younger subjects. For older subjects the proportion recalled by subjects forced to study missed items during training (standard procedure) rises dramatically on the posttest. The other two conditions do not seem to change between pre- and posttest. Thus the only evidence for improvement on the posttest occurred in the older children who were forced to study missed items in training. The mean standardized selection scores are presented in Figure 4, together with the comparable scores from the pretest. The same pattern appears here as was seen

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Insert Figure 3 about here

Insert Figure 4 about here

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for the recall scores. Only the older children from the Standard condition show any change between the pre- and posttests.

Was this failure to find a pretest-posttest difference in all but one group a failure of training or transfer? To answer this question we must consider the training data which are presented in Table 14. Only recall data are available in training as the experimenter selected the items for study. Younger subjects improved reliably across trials and trial blocks in the creeping condition and showed very little improvement in the other two conditions. Older subjects improved reliably in the standard condition, across both trials and trial blocks, and showed no improvement in the random condition. Note, however, that there is some improvement across trials, although not across trial blocks, for older subjects in the creeping condition. Evidence for improvement was found then in both younger and older children in the training phase and therefore the lack of a posttest improvement in the younger children can be attributed to a transfer failure.

A summary of the training results would be that younger children benefit from an imposed creeping strategy but not from an imposed standard (Masur et al., 1973) strategy. Older children benefit most from an imposed standard strategy and little from the creeping strategy or the random selection. This pattern of results appears to confirm that strategies, to be successful, must be compatible with the cognitive competency of the subjects. Forcing subjects to study according to an adult strategy (standard) only helps older children who can meet (to some extent) the demand characteristic of that strategy.

(c) Span estimation. At this point we decided that, at least for very immature subjects, a good research strategy would be to concentrate on direct training of metamnemonic behavior rather than the indirect approach adopted by Brown and Barclay (1976) and Brown and Campione (1977a). Another change of focus was a shift away from monitoring of strategy utilization, the subject of both the Brown and Barclay and the Butterfield and Belmont studies Concurrently applying a task-relevant mnemonic and monitoring its success or failure appears to involve a complex coordination of introspection and overt behavior, a coordination which is late developing in both normal and retarded populations. In light of our prior failures we decided to consider a simpler form of metamemorial awareness the ability to estimate one's own span, which seems to underlie any subsequent attempts to introduce and control specific strategies (Brown, et al., 1977). If a child is not aware of the extent of his memory limitation he can scarcely be expected to introduce steps to remedy his shortcomings.

The span estimation task was also chosen because it has been the subject of prior training attempts, with somewhat contradictory results. Whereas Yussen and Levy (1975 found preschool children remarkably impervious to feedback from a practice trial revealing their recall inadequacies, Markman (1973) found 62% of kindergarten children responding to ten explicit training trials. Both age and extent of explicit training could be responsible for these differences. As both explicit and extended training is usually needed to effect an improvement in retardates' use of specific memory skills (Butterfield & Belmont, 1977; Campione & Brown, 1977; Rohwer, 1973), we decided to provide extensive explicit training on the metamemory task. In short, we hoped to provide an optimal training experience in order to assess whether such training could lead to long-term improvement of the younger child's knowledge concerning his own memory limitations.

Two groups of naive educable children (MA 6 and 8) were shown arrays of ten pictures (exposed simultaneously) and asked to predict how many they would be able to recall.[2] These predictions were then compared with their (subsequently determined) actual recall. Individuals whose estimates were within two items (±2) of their actual recall were termed realistic estimators; those whose guesses were more than tw items in error were termed unrealistic estimators. Only 31% of the older children and 21% of the younger ones could be classed as realistic, with the remainder overestimating their performance levels (most predicted they could recall all ten).

All children were then given a series of ten training trials on which they were required to estimate their performance and then to recall. For half the participants at each MA level, those in the feedback condition, explicit feedback was provided, reminding them of their prediction and indicating visually and orally the number of items they had actually recalled. This feedback followed each estimation-recall series. The remaining children predicted and recalled, but no explicit feedback was provided. After training was completed, three posttests were given, the first, one day after training, the second , two weeks after training, and the third, approximately one year after the original posttests.

The data of major interest are shown in Figures 5 and 6. In Figure 5 the proportion of realistic estimators are shown, separately for the two MA levels on the pretest and on each of the subsequent posttests. In general, the younger children showed some improvement on the first posttest (one day after training), but were back to baseline levels following two weeks. For the older children, the initial improvement was more dramatic, and was better maintained over time. Even one year later, the proportion of realistic estimators (.56) was considerably larger than it was prior to training (.31).

Insert Figure 5 about here

In Figure 6, the data of only the originally unrealistic estimators are considered; further, the results are broken down in terms of both MA level and the feedback variable. Students classed as realistic initially remained so throughout the experiment. Luckily our training did not cause them to regress. Considering the first posttest of the originally unrealistic children, 65% of the older individuals became realistic independent of the feedback condition. Of the younger trainees, 62% of those given

Insert Figure 6 about here

feedback became realistic, whereas only 9% of those not given feedback improved to th point of being realistic. Looking at the data from posttest 2, the older individuals remained unchanged; 60% were still realistic, and there was no effect of the feedback variable. However, for the younger children, only 18% of those given feedback remained realistic and no children in the no-feedback group could be classed as realistic. Thus, considering only the first two posttests for the older children, traini with or without explicit feedback, was sufficient to bring about realistic estimation and the effect was durable. The pattern obtained with the younger students contraste sharply; there was significant improvement on the first posttest only when explicit feedback was provided during training; even in this case, the effects were not lastin as the proportion of realistic estimators dropped from .62 on posttest 1 to .18 on pos test 2. The effect of providing explicit feedback for the older children was noticed only on the final posttest. The proportion of realistic estimators remained unchange in the feedback condition, whereas for those not given feedback during training, only 20% remained realistic approximately one year after training.

(d) Summary. The results of these initial experiments indicate that mildly retarded children have problems estimating their own performance, both prior to and during the time they are performing on a task. It also seems clear that, for the younge children, information about their performance needs to be explicit before it will hav any effect, and that continual prompting may be necessary to maintain performance. Also, in all three experiments, a clear developmental trend was found regarding the durability of training effects. Whereas training had a relatively durable effect wit the older children, the effects with the younger ones were extremely short-lived.

2. Generalization

The limited success of our attempts to find maintenance of training had the effe of dampening our enthusiasm for tests of generalization. However, as the older children in all studies did show adequate maintenance we did include specific tests of generalization in the Brown, et al. (1977) study and we are currently looking at recall-readiness generalization in the older children (Brown & Campione, 1977b). In addition to tests of specific skill generalization, we have also considered a more general transfer phenomenon, that is, are there any differences between the children who have participated in several memory and metamemory training studies and comparable naive populations, either in terms of general improvement on each new task or on a questionnaire investigation of general metamnemonic awareness?

Before continuing to describe our general and specific transfer data we should make clear what our criteria for generalization are. Many studies which have claimed generalization we would regard as measuring maintenance, for they involved only the use of a new stimulus list on the generalization task. We use new stimuli throughout our studies and assume that continuing the trained activity on new lists to be a test of maintenance. Generalization tests involve not only new stimuli but some other change as well, however minimal that change might be. We will return to the question of adequate criteria for generalization later (section IV. F.).

(a) Specific generalization. The only completed study where we included specific tests of generalization of training was the span-estimation training study of Brown, et al. (1977). For pre-, post, and training tests, a modified version of the span-estimation task was used. That is, on each trial the child was confronted with a large card containing 10 small pictures and he was asked to estimate how many he would recall. On the pre- and posttests the seriated task used by Flavell et al. was also included. Here the items were exposed incrementally (1, then 2, then 3, up to 10) and on each exposure the child must indicate if he can recall a list length that large. The proportion of realistic estimators on the seriated sets was low for both groups and varied little as a function of time of test (.18, .18, .20, .15 for older subjects on the pretest and three posttests, compared with .03, .07, .03, .05 for younger children). Even though there was an improvement, particularly among the older children as a result of training on the 10-item task, this improvement did not generalize to the very similar seriated test.

An additional generalization test was given on the day following the second posttest. The subjects were shown twenty 10-item cards each containing the numbers 1 to 10. Ten of the cards contained the numbers in numerical order starting with a number other than 1; the remaining cards contained the numbers in a randomized order. The subjects went through the 20 cards and indicated how many they would be able to recall on each. Next, actual recall was assessed on both types of materials. Finally the cards were paired, one random and one organized and the subjects were asked which set would be easier to recall and why. Thus two sets of cards were used, organized and disorganized Predicting 10 items on an organized list (e.g., the numbers in serial order) could be a realistic estimate, while predicting this way would be unrealistic for the random lists. For this reason we considered the two list types separately. The data from random lists only are presented in Table 15. Consider first the originally unrealistic subjects. Apparently there is no evidence of generalization following training on the highly similar 10-item picture task. The proportion of realistic subjects is low for both young and old subjects and the number of children guessing 10 is very high. Consider next the originally realistic subjects (collapsed across feedback conditions). Here the picture is quite different. The mean difference scores (predicted vs. actual) for both young and old subjects fall within the realistic range (±2). Approximately two-thirds of the originally realistic subjects are realistic on the number generalization tests and the number of 10 guessers is low.

Insert Table 15 about here

Turning to predictions on the organized lists, a similar pattern emerges. The proportion of subjects who accurately predict they will recall 9 or 10 items (e.g., appreciate the organization of the lists) is .67 and .58 for the young and old originally realistic subjects. No originally unrealistic young child does this and only .26 of the older children predict 9-10 items.

Finally, the children were given ten forced-choice trials, where an organized card was paired with a random card, and asked which would be easier to recall. The number of subjects indicating that organized sets of numbers would be easier to recall than random sets (i.e., predicted organized > randomized on 8/10 trials) are included in Table 16. Again, approximately two-thirds of the originally realistic subjects predict that the organized cards will be easier to recall while the trained realistic do not seem to differ from the unrealistic subjects.

Insert Table 16 about here

Thus, our one systematic attempt to find generalization of specific training (completed so far) was less than encouraging for there was little evidence of generalization as a function of training. Those subjects originally realistic on the training task did show transfer to all the generalization tasks, which suggest that the tasks themselves were adequate tests of transfer for efficient subjects; however, the trained realistic subjects were not so flexible. It should be noted that the generalization tasks were highly similar to the training task; in all, the basic requirement was to estimate one's own span for a 10-item list. The seriated method included the same type of stimuli but the task format changed slightly. In the number estimation problem the task format (10-items) was preserved but the stimulus type changed. Both are very minor changes and both have been suggested as excellent first steps to provide an optimal situation for generalization (Brown 1974; Campione & Brown, 1974). Yet none was found even in the older subjects. Maybe the dismal failure of this training program lies in the fact that training took place on one task only and the information gained was truly "welded" to that specific task (Shif, 1969). If this is true then the next step must be to provide training in a variety of similar tasks, all requiring the same strategy, and then look for generalization to new tasks which fall within the same class as the training tasks. A second reason for failure to find generalization is that no training or explicit mention of generalization was given to the child (see section IV. F.). In any event, considerable time and effort will be needed in the search for the elusive evidence of generalization of cognitive training in retarded children.

(b) General transfer. Our initial attempt to inculcate generalization of training was not encouraging. Our other indices that educable children do not show generalization very readily stem from our comparison of experienced and naive subjects. First, we have never found reliable differences between experienced and naive subjects entering a new experiment (Brown & Barclay, 1976; Brown & Campione, 1977a; Brown et al. 1977; Brown & Lawton, 1977). Whatever the effects of training they certainly are not sufficiently robust to contaminate our subject population for further studies; nor to educate them!

In an attempt to examine generalization systematically we used the Kreutzer et al. (1975) questionnaire of general metamnemonic awareness. This was administered to four groups of children, all from the same school district: MA 8 naive (N = 28), MA 8 experienced (N = 30), MA 6 naive (N = 21), and MA 6 experienced (N = 40). The experienced children had taken part in at least two metamemory training studies, and, in some cases, other problem solving and memory experiments. The naive children had never served as experimental subjects to our knowledge. The idea was to see if experienced subjects exhibited greater general awareness than did the naive children on the wide ranging questionnaire items.

Some of these data have already been presented (see Tables 2, 3, 4, 8, 11, and 12 and the observant reader will have noted the dramatic lack of an effect due to experience. No consistent patterns emerged. Experienced subjects did not show more awareness than naive children even on those subtests which were relevant to specific training they had received, i.e., children trained to rehearse did not indicate that rehearsal would be a reasonable activity to employ, or would result in better performance. There was some slight evidence that experienced children were more able to give adequate explanations of their responses but they also produced more explanations and this was thought to be the result of their greater familiarity and ease in talking to the experimenter who conducted all prior studies with the population. The only reliable difference to emerge in the entire study occurred on the initial item where the children were asked whether they were good at remembering; many more of the experienced subjects believed that they were not (MA 6, naive = .24, experienced = .46; MA 8, naive = .46, experienced = .64). Thus the only tangible effect of two years training was to alert the children to their own memory deficiencies, but not to possible methods of overcoming them, a less positive outcome that we would have wished.

IV. Metamemory: New Thoughts and Old Problems

When the original studies of metamemory in children first appeared, the general response was one of excitement; here was surely a more intelligent way of studying memory development! The appearance of such studies reflected an apparent shift of emphasis away from a concentration on the child's rote-learning skills toward a consideration of the child as an active agent in knowing, furthermore, an active agent influenced by a variety of hitherto unconsidered forces. The development of memorization skills and knowledge concerning memory began to be considered, not as separate phenomena, but as integral parts of the cognitive development of the child seen in cultural context. Although we would argue that this shift in emphasis was an exciting and fruitful development, we have some hesitations concerning the direction the field appears to be taking. Now that the study of metamemory development is over five years old, it seems reasonable to stress these reservations and consider problems that seem common to the area. We would like to point out that many of the criticisms apply to our own work at least as much, if not more, than to any other research.

A. Beyond Demonstration Studies

The history of developmental research into aspects of memory is relatively short and such endeavors did not become part of the mainstream of research with children until the sixties. During this decade, and on into the seventies, we witnessed an upsurge of interest centered around the young child's ability to use active strategies of learning. The majority of these studies concerned rote-learning skills, particularly those of rehearsal and categorization, used to ensure reproductive recall of isolated lists of materials (Brown, 1975). Interest in this topic resulted in literally hundreds of studies showing that the developmentally young were (a) deficient in the use of such skills, (b) could readily be trained to use strategies, and (c) tended to abandon the trained skills unless explicitly prompted to continue.

In the late sixties and early seventies, the first batch of metamemory studies appeared. These also focused primarily on the child's knowledge concerning basic rote-learning skills, in fact the same two, categorization and rehearsal. Here too, history is beginning to repeat itself, for we are seeing an increasing number of demonstration studies showing that the same population that was deficient in the use of basic mnemonics is also less than well-informed concerning the utility of such strategies. We anticipate, pessimistically, a similar spate of spin-off demonstration studies over the next few years aimed at making this point crystal clear. We have contributed to this proliferation in the past, and will probably continue to do so in the future.

Although demonstration studies add to our growing knowledge of the memory deficiencies of immature thinkers, and the initial studies in this area must be regarded as extremely important contributions to that knowledge, the value of a proliferation of such demonstrations must be doubted. Do we really need many more studies showing that young children do not often think about thinking, remember much about remembering, or have not learned much about learning? What is needed is the development of a theory which would enable us to direct empirical research intelligently, to confine our demonstration studies to areas where they are still needed and to enable us to advance forward, rather than sideways in our attempt to understand the development of thinking. We realize that the development of such a theory is not something that can be accomplished overnight. Developmental theories in general suffer from several characteristic faults, e.g., they are so general that there is no means of refuting them or so specific that their range of generality is limited; they concentrate on developmental issues to the virtual exclusion of the processes that are the subject of the development or they concentrate on process and ignore the thorny problem of development. The call for theory is not a minor one.

On a more practical plain, isolated demonstration studies can be discouraged in favor of more in-depth and detailed analyses of the particular paradigms employed. Again we would not like to encourage a spate of research on paradigms, the literature is too full of examples of questions being lost in favor of detailed analyses of the tasks employed. However, a middle ground does seem to be needed. For example, there are only two metamemory paradigms which have been investigated more than once, recall-readiness and span-estimation, two of the initial tasks introduced by Flavell et al. (1970). Both were found to have interesting procedural flaws leading to an overestimation of the child's metacognitive skills. Increasing the list length beyond span drastically limits performance on the recall-readiness task (Brown & Barclay, 1976; Markman, 1973). On the span-estimation task the procedure of stopping at the child's first indication that his capacity was overreached may also have produced an over-optimistic picture of metamemory in young children (Brown, et al., 1977). Uncritical acceptance of an isolated demonstration study, without a firm understanding of the task demands, can be a dangerous pasttime.

B. Metamemory or Meta Rote Learning?

Not only have studies in metamemory been largely restricted to isolated demonstration studies but they have concentrated almost exclusively on the child's knowledge and control of a few simple rote-learning skills. A notable exception to this statement must be Flavell's interest in realistic search behavior both internal and external (Drozdal & Flavell, 1975; Flavell, 1976a). It is currently fashionable to deplore the undue concentration on skills of rote learning for reproductive recall, particularly of meaningless, isolated lists of materials (Brown, 1975; Jenkins, 1973), but this criticism is rarely raised in conjunction with the metamemory literature. Yet a child's knowledge of his ability to rote learn laboratory materials is not the only form of metamemory. Indeed one could argue that the utility of such knowledge would have a limited range of applicability (Brown, 1975, 1977b). For much of what we must learn requires gist recall of connected discourse, where common mnemonic techniques used to ensure rote recall of word lists may be no longer serve a useful function.

If demonstration studies of metamemory are to proliferate, they may concentrate more fruitfully on areas where we lack even basic information. For example, examinations are needed of the child's knowledge of his ability to retain the essential ideas of a written or spoken communication, to understand instructions, to distinguish between situations where recall must be reproductive or reconstructive and between situations where deliberate memorization is needed or not needed, or on any of a host of other intelligent activities that are involved in remembering (see section IV. F. and V. D.).

One reason why we have limited information concerning such metamemory in children, or adults for that matter, is because we know little about the way mature thinkers solve such problems. Knowing a fair amount about rehearsal and taxonomic organization we can safely ask, does the child know too? Knowing little, or nothing, about more complex memorization skills, it is hard to define what the child should know. Collins et al. (1975) have provided glimpses of the rich repertoire of cognitive pyrotechnics graduate students can bring to his Socratic dialogue game. What is needed is a similar set of protocols from coherent adults and bright children faced with a variety of memory situations (Brown, 1977b). A good starting point would be study skills, for every student is required to attempt them, every student must be aware of the strengths and limitations of certain activities, and some students may be aware of such niceties as the match-mismatch of certain activities and the end goal (Brown & Smiley 1977b). Knowing more about such awareness in adults we may be in a better position to assess what it is that the less mature learner does not know, needs to know, and possibly, could be trained to know.

C. Developmental Trends

The restriction of attention to the child's knowledge concerning (a) basic rote-learning strategies, (b) the distinctions between memorization and perceiving, and (c) his less than perfect capacity for rote remembering, has led to the impression that metamemorial development is rapid and functionally complete by third grade. This is not to say that anyone believes that development is complete by this time and it is encouraging that there is a consistency in the age at which children acquire knowledge of the particular subset of skills that have been studied. In the Kreutzer et al. (1975) questionnaire study there is impressive evidence of a ceiling in performance at around third grade for the majority of problems set. In addition most of the empirical studies indicated that third grade or before is the point at which awareness is attained by the majority of children. Thus both recall readiness and span estimation improve little after second grade (Flavell et al., 1970; but note objections cited above). On the study-time apportionment task there is improvement between first and third grade, but third graders behave very much like college students (Masur et al., 1973). Moynahan (1973) found little difference between third and fifth graders in predicting task difficulty for categorized and uncategorized lists. Indeed, if one were to exclude the youngest group in many of the existing metamemory studies (e.g., the kindergarten or first grade sample) one would be left with no reliable developmental differences! The pattern seems fairly consistent across tasks; by third grade children know a fair amount about rote memorization of lists.

When the task is more complex, however, as in judging the difficulty of prose passages or the importance of various aspects of texts (Brown & Smiley, 1977a, 1977b), a much later age would be suggested for efficiency. Throughout the review of the literature we have attempted to illustrate the importance of the effects of task difficulty. Whether or not children will be judged aware or unaware or will be attributed with metacognitive insights, depends on the level of difficulty of the task and the match between the task demands and the child's existing cognitive skills (Brown 1975; Brown and DeLoache, in press). A child who knows a great deal about organization when the basis of that organization is taxonomic categorization may know little or nothing concerning organizational principles underlying text materials.

Two other points concerning developmental trends will be treated more fully later and will be mentioned only briefly here. First, Kreutzer et al. raised an important issue when they suggested that the knowledge a middle school child may have about certain facets of memorization may have little to do with how he will perform on such tasks. For example Danner (1974) pointed out that knowledge concerning important organizational features of texts considerably precedes the ability to select suitable cues for retrieval purposes. Similarly, knowing that an active strategy will aid recall does not necessarily mean that a child will elect to use that strategy himself (Brown, et al., work in progress).Later development may be characterized by an increasing coordination between what one knows about memory and what one does about memorizing. We will return to this in the section concerned with predictions and performance.

Second, research to date on the development of metamemory has been characterized by an emphasis on the early signs of cognitive self-knowledge and the emergence of primitive precursors of metamemory. This is reflected in the push to find evidence of metacognition at as young an age as possible, and in good hands, this has resulted in some exciting and ingenious work (Wellman, Ritter & Flavell, 1975; Wellman in press). Such work is encouraged and will continue to be encouraged by the pervasive influence of "anti-structuralism" (Belmont & Butterfield, 1977) in American developmental psychology. In an effort to prove that, contrary to (a misinterpretation of) Piaget, preschool children can perform rationally and, contrary to (a misinterpretation of) mediational learning theories, preschool children can think, demonstrating evidence of such intelligence in preschool children has become an end in itself. Thus the "game" for many neo-Piagetians is to show evidence of concrete operations at a younger and younger age. However, there is less emphasis on attempts to define the limits of this early awareness by employing stringent criteria of mature comprehension. The child's response(s) are taken at face value as indicative of intelligent understanding of the concept studied, before a realistic appraisal is made of the robust nature of that understanding (Brown, 1976a). The same approach dominates the emergent metamemory literature and, therefore, more emphasis on the "testing of the upper limits approach" should be made, as the "how young can they do it" school is fairly represented.

D. Predictions and Performance

One of the most persuasive arguments in favor of studying metamemory development is that there must be a close tie between what one knows concerning memory and how one goes about memorizing. If it can be shown that the child does not appreciate the utility of rehearsing a telephone number, the fact that he does not choose to rehearse would not be surprising. Similarly, if the child could be made aware of the importance of strategic intervention, then he would supposedly choose to behave strategically. Evidence for this close correspondence is notably lacking. Admittedly, there have been few attempts to study this tie between memory and metamemory systematically. What evidence we have comes largely from post hoc examinations from studies which were never intended to address the question. But there is some direct observations of the match between prediction and performance, and these have so far provided less than impressive support for a close tie.

Consider first the limited data we have. Salatas and Flavell (1976) and Moynahan (1973) examined knowledge concerning categorization and recall. Both failed to find a direct link. Moynahan found that awareness of the effects of categorization was not related to actual performance on categorized vs. uncategorized lists. Similarly, Salatas and Flavell (1976) found that first graders who had not categorized were as likely as those who had categorized to indicate that categorization would aid recall. A complete separation between prediction and performance, however, was not suggested by either study. Salatas and Flavell did find that children instructed to remember gave more correct answers on metamemory questions and Moynahan (1973) found better responses to metamemory questions after, rather than before, active attempts at remembering. Experience with remembering does have some affect on metamemorial awareness but not the direct influence that one would like.

The absence of a direct link between predictions and performance was well documented in young normal and educable retarded children (Brown et al., work in progress, see section III. B. 4.). Asked to predict which modelled activity would result in superior recall, all the MA 6 and MA 8 children indicated the superiority of an active strategy (in contrast to preschool and first grade normal children who were not so sensitive). Given the exact task to perform themselves, immediately after viewing the model, only a minority actually performed the efficient strategy themselve (see Table 10). By third grade the majority of children elected to perform the strateg they had predicted to be most efficient, but even for these older children, the relationship was less than perfect. Items from the Kreutzer et al. questionnaire also show this pattern. Children who predicted that studying longer or more actively will lead to better recall do not necessarily say that they would act this way themselves.

Flavell and Wellman (1977) point out that there are many reasons why the ideal relation of metamemory and memory may not be found.

> Suppose a person judges that categorized stimuli are easier to recall than noncategorized ones. Would he inevitably use categorization as a storage strategy, given obviously categorizable stimuli? Not at all. He may know about categorization but think that something else might be better yet in this situation. He may think the list easy enough to use simple inspection for storage. He may have enough knowledge to judge that categorization would be a good strategy, if asked about it, but not enough to think to utilize such a strategy on his own. Lastly, there are undoubted gaps between metamemory and memory behavior attributable to Original Sin. Moral action does not always accord with moral beliefs, and similarly, we do not always try to retrieve information or prepare for future retrieval in what we believe to be the most effective ways. (Flavell & Wellman, 1977, pp.)

Like Flavell and Wellman (1977) we believe that there should be "a development of metamemory judgment, of memory behavior and a developing coordination between the two." Yet we know of little evidence to support this statement. All the actual data cited above were gathered from children with MAs of eight years or below. Here the relation of metamemory and memory is weak. In our modelling study (Brown et al. work in progress) we did know an increase in older children in the desired correspondence but further investigations of the development between growing metamemory awareness and improvement in actual memorization behavior are still needed.

To reiterate another point made by Flavell and Wellman the "causal chain may be more clearly and exclusively metamemory → memory behavior later in development." Yet how does this development progress? Does the dawning awareness of metamemory precede improved efficiency of memory behavior (metamemory → memory behavior)? Does increasing experience with memorization lead to metamemorial awakening (memory behavior → metamemory)? Or is the process a complex cross fertilization of the two (memory behavior ↔ metamemory)? Everything we know about cognitive development would point to the third alternative for one can scarcely expect the child to become enlightened with metamemorial knowledge by divine intervention, prior to repeated experience with a variety of memorization tasks. The coordination of knowledge and actions concerning memory may be the essence of development after the early school years. Investigations of the hypothesized increased coordinations have barely begun.

Of both theoretical and practical importance is the nature of the experiences which would effect such cognitive growth. Flavell and Wellman (1977) suggest that general experience with school and school tasks would provide the impetus for this development but the lack of sophistication of high school children at assessing their own capacity would suggest that such indirect influences might not be too efficient (Brown 1977b, Brown & Smiley, 1977a, 1977b). Indeed, it may be the case that such general improvements in intelligent understanding cannot be taught explicitly. Yet, for those interested in instructional psychology, the field is wide open to attempts to identify essential experience which might effect improvement. This is particularly important if one is interested in the slow-learning child who may never acquire such insights unless explicitly directed.

E. Measurement and Criteria of Awareness

As the study of metacognition is in its infancy, it is not surprising that refined measures for assessing metamemorial awareness have yet to be developed. But there are examples of the growing pains experienced in other related fields and it is economical to attempt to benefit from others' mistakes. We know from related areas of cognitive development of the problems associated with accepting a child's verbal responses as an index of what he knows. What a child says he has done, or will do, is not necessarily related to what he does. Reliance on verbal responses and justifications is a risky venture when the advocate is a child. As the majority of hard (soft) data in the metamemory area consist of just such verbal self-reports, the problem of the criteria for evaluation of data is a crucial issue.

The problem of measuring metamemorial judgements is a sensitive one for we are concerned not with what the child is doing, but with what he thinks he is doing and why. A direct method of inquiring into what a child knows is to ask him. Some examples of the problems of this approach may prove illustrative. One experimenter responsible for running the modelling study (Brown et al. work in progress) asked her seven-year-old son how he would study the pictures (after he had seen the video-tapes). He replied, without hesitation, that he would look at them; he always did that if he had to remember. Given the list, he carefully put all the pictures into taxonomic categories, spatially separated the categories and proceeded to scan them systematically. Asked what he had done to remember, he replied that he just looked at the pictures just like he said he would.

Less anecdotal examples of the pitfalls of taking a verbal response at face value have been reported throughout the literature review. Perhaps, the most illustrative is the difference in span estimation obtained by Brown, et al. (1977) when the index of awareness was the child's first indication that his capacity was overreached, or when the child was allowed to continue estimating up to the maximum list length of 10 items. Many of the children who would have been judged realistic if we had stopped at the first response were quite happy to assert that a list of five was too difficult while one of six was not, to claim that seven was too many but eight was O.K. Whatever this tells us about the child's metamemory, it certainly tells us to beware of accepting a single verbal response as a measure of awareness.

Kreutzer et al. attempted to overcome this problem by requiring multiple responses to their test questionnaire, including adequate justification. The match between single yes/no answers indicating awareness, and adequate justification increased dramatically with age. Would demanding adequate justifications solve the problem? Kuhn (1974) has considered this problem in the context of Piagetian conservation studies. Apparently there is more than one school of thought. Brainerd (1973) believes that justifications are inappropriate for evaluating the child's understanding of a problem, for operativity is supposed to precede the ability to express such knowledge linguistically. The risk of Type II errors is a problem as many children may well possess the requisite cognitive skills but fail to express them adequately. Brainerd (1973) advocates the use of yes/no, same/different responses, but as Kuhn points out, any dichotomous choice method is sensitive to response bias effects, known to be developmentally sensitive (Brown & Campione, 1972). The dilemma is that demanding justification of responses entails the possibility of Type II errors but replying on dichotomous responses risks the possibility of Type I errors. Kuhn's solution is the use of converging operations. As rich a variety of responses as possible should be elicited and the degree of awareness judged against the total picture revealed.

As the responses that make up the majority of metamemory data are also dichotomous decisions or justifications, the same solution seems worthy of investigation in this area. Many different measures of awareness should be obtained, and at the very least, one should avoid accepting a single response as the only measure of the child's knowledge (Brown, et al., 1977). There is also an obvious need to consider the problem of reliability of the measures obtained.

In the strategy-choice modelling task (Brown et al. work in progress) .23, .44, and .28 of normal four-year-olds, MA 6 and MA 8 retardates respectively, were inconsistent in their choice of a preferred strategy when multiple measures were employed the necessity of obtaining reliability data is clear. Note that Brown and Lawton (1977) found that children, sensitive to their own feelings of knowing in one situation did not necessarily show the same sensitivity in a variant of that task. Albeit there were severe selection problems in those studies, but it further cautionary tales are needed, note the "dishonesty," or "creative flexibility" depending on your viewpoint, of the children who deliberately failed a recall test so that they could play the popular feeling-of-knowing betting game. Of course they had a reliable feeling of knowing concerning future recognition accuracy for items they could perfectly well have recalled.

Thus we agree with Belmont and Butterfield (1977) that measurement is a crucial problem in this area, and we would argue in favor of convergent operations (see section V) in the quest for quantifying and qualifying the degree of awareness children have of their own mental operations.

F. Training and Transfer

Another powerful motivation for the current interest in metamemory, certainly the reason for our own interest in the area, stems from the controversy concerning the limited success of attempts to train specific mnemonic strategies in those who do not think this way. The argument is simple, if young children are totally unaware of the utility of mnemonic aids, why should they benefit from instruction? If trained to rehearse, they will rehearse, especially if the situation remains unchanged and they receive continual reminders. But why should they then be expected to use their new skills insightfully if the reason for the activity was never made clear?

This leads us to the interesting question concerning which aspects of performance one should attempt to train deliberate skills of remembering or the executive control of these skills. Butterfield and Belmont (1977) raised this issue by contrasting what they believed to be different positions taken by Brown (1974) and Butterfield, Wambold, and Belmont (1973). They characterized our position as one of opting for the training of individual strategies for the solution of specific tasks in the hope that the executive function would emerge as a result of mastery of a suitable subset of skills. In contrast, their preference was to focus on the executive function itself. Although this appears to be a difference of opinion, the importance of the distinction fades when one considers practical steps necessary to instigate a training program; for it is difficult to imagine how to train the executive control of strategies in the absence of a set of strategies to control. Thus, while it is feasible to attempt to inculcate planfulness by suggesting that the child "plan ahead," "be economic with cognitive effort," "use only the correct plan and then only as long as needed," etc., practically, it seems that one must proceed by initially training some memorization skills before attempting to induce the monitoring and control of these strategic behaviors. Butterfield and Belmont, in essence, agree with this position and, therefore, the difference of opinion is an artificial one, for they state "since the control processes (skills, etc.) are the subject of the executive function, they would seem to be the most promising indices of its operation. A firm basis of measurement for the control processes would therefore precede measurement of their overseer" (Butterfield & Belmont, 1977, p.9). We believe their description of our position to be inadequate for we did state in the 1974 paper that "once a serviceable skill, or subset of skills had been inculcated, the next step would be to devise techniques to train retarded children to monitor their own strategy production and to evaluate realistically the interaction between the task demands, and their own capacity and repertoire of specific skills" (Brown, 1974, p.102).

The apparent disagreement disappears under scrutiny; both positions advocate training preliminary skills as an essential prerequisite for the study of executive control. However, what looked like a difference in emphasis perhaps reflects a more fundamental difference in the direction that training attempts should take. In a subsequent paper, Belmont and Butterfield (1977) seem to have changed their emphasis in that they call for detailed task analysis of both the training situation and all subsequent tests of transfer, e.g., train the specific skill. We will now change our emphasis and call for training, not of individual strategies, but of ways of approaching problems in general.

This argument needs elaboration. Belmont and Butterfield (1977) argue cogently for detailed task analyses of individual laboratory tasks and the strategies that subjects may perform in them. The degree of detailed analyses that can be undertaken is well illustrated by their ten-year effort to refine the cumulative-rehearsal fast-finish strategy deemed optimal in their paradigm. The effects of such detailed task analyses are clear. Given an intimate understanding of all aspects of the optimal strategy it is possible to train children efficiently, to diagnose why training does not result in optimal performance, and to bring the level of performance at least to the standard set by untrained adults (Butterfield et al., 1973).

The main strength of the detailed task analysis approach to training mnemonic strategies is illustrated in this admirable set of studies, particularly those reported by Butterfield et al. (1973). If the aim of training is to see how close to mature performance one can render children's behavior, this approach is highly successful. Theoretically such data are invaluable for they demonstrate that one interpretation of a "structural limitation" (Brown, 1974) position is incorrect. If training fails, one should not implicate some fundamental capacity limitation of the child but attempt to refine training (Belmont & Butterfield, 1977; Brown, 1974). The task analysis approach is also invaluable from a practical standpoint, if the desired end product is to improve performance on the training task itself. Gold's (1972) work with severely retarded individuals is an excellent case in point. Severely and profoundly retarded institutionalized people can be quickly trained to perform complex assembly jobs if the task is broken into easily manageable subunits, an intelligent task decomposition achieved through detailed task analysis (Wade & Gold, 1977). The goal of the training procedure is to achieve quick, errorless performance on the training task, for, armed with this skill the hitherto unemployable individual can earn a living wage (Gold, 1973).

The aim of those engaged in cognitive instruction is generally assumed to be somewhat different. Rather than regarding the goal as excellent performance on a specific task, the desired end product is to effect a general improvement in understanding, a much more demanding specification. This aim can again be defended both theoretically and practically. Theoretically, one could argue that without evidence of broad transfer, training may have resulted in the mastery of a rote rule, but may not have produced any real "structural change" (Kuhn, 1974) or general advancement in the child's knowledge of the world. Thus there are at least two ways to consider the "anti-structuralist approach" (Belmont & Butterfield, 1977). Demonstrating adult-like performance on a single task is sufficient evidence for those who are interested in proving that intellectual immaturity is not necessarily an impediment to efficiency on any one task. The extreme position would be the claim that anything could be taught to anyone under the appropriate training conditions. Another version of a structural limitation position is one more akin to Piaget's, that there are limitations to the young thinker's ability to reason; mere training on a particular task will not affect this ability until the appropriate level of maturity is reached. Intellectual maturation may be accelerated, but training can achieve only a small increment (Inhelder, Sinclair, & Bovet, 1974). Within the memory training field, advocates of this more conservative form of "structuralism" look for generalization as the index of successful training.

The problem is not one that Belmont and Butterfield ignore but they appear to have a different end result in mind. Their aim is to "bring children up to adult levels of performance {on a specific task} , in every measurable aspect;" by providing a plan of sufficient detail that "anybody whose thoughts are put together according to that blueprint would recall very well." Given such a plan young children should perform "exactly as if they had invented it themselves." "Instructional researchers and their young subjects are thus evidently engaged in the same enterprise and it is unimportant who makes the executive decision so long as they are made well." Finally, they assert that the most striking aspect of the instructional approach is to instruct the child "how or what to think."

This statement, how or what to think, encapsulates the difference between the two approaches for there is an enormous gulf between training a child how to think and training a child what to think. The knowing how and knowing what controversy has played a prominent part in the history of educational philosophy and is still active today (Broudy, 1977). It is isomorphic with Greeno's (1976) distinction between cognitive and behavioral objectives of instruction. Training a set rule or recipe (Holt, 1964) can effect significant improvement on a task, but, we would argue that without a concurrent understanding of the reason why the skill must be used, it is unlikely that the result would be an improvement in the child's knowledge of how to think. We need not add here details of the long discussions of discovery learning vs. rote learning and refer the reader back to section III. D. 3. for examples of blind rule following.

Although there has been considerable interest in the need for transfer as a criterion of general cognitive improvement, the review of the literature illustrates the dearth of experimental endeavors in this area, an empirical gap generated not by lack of interest but because of the formidable investment of time and effort needed to undertake such investigations. Belmont and Butterfield (1977) advocate an extension of their task analysis approach to a consideration of transfer; "the investigator who would demonstrate transfer must thoroughly understand both the task he uses during training and the task he uses to test transfer." Let us emphasize that they do mean thorough for they argued that both training and transfer tasks must be subjected to the type of indepth analysis they have lavished on the cumulative rehearsal task. Failure to make an equally indepth dissection of the transfer task would render the investigator incapable of interpreting transfer failures. A failure to perform adequately on transfer could be due to the trainee's inability to see the relation of the trained behavior to the new task, the usual interpretation, or to his inability to execute some other component of the transfer task which neither he nor the investigator fully appreciate.

The only answer then is to consider transfer from one well-analyzed task to another. We know of only one attempt that even approached this criterion and that was a failure. Retarded children who had been trained to cumulatively rehearse on a keeping-track task (Brown et al., 1973) and had maintained this activity over a six-month retention interval (Brown et al., 1974) were given the Belmont and Butterfield probed-recall rehearsal task as a transfer test. Accuracy scores of naive and trained children were identical and poor. More important, there was no evidence of rehearsal activity (pause patterns, observed overt behavior) in either group (Campione & Brown, 1977). True, it could be argued that the transfer situation was less than ideal; the transfer test was taken some time after the maintenance task, and the keeping track lists consisted of four items, while the probe recall lists contained six. But both tasks called for cumulative rehearsal in sets of three, the trained strategy, and there was no evidence of activity even on the first three items of the transfer task. We would not take this as the strongest evidence that such transfer could not be obtained, however, we were not encouraged by the results. Our interpretation of the Belmont and Butterfield position is that what would be needed before firm conclusions could be reached would be detailed task analysis of the first task, detailed task analysis of the second task, detailed task analysis followed by training on the non-common elements of the two tasks, detailed analysis of the transfer setting, detailed analysis of--- . Pragmatically one has to face the problem of time and to assert a principle of cognitive economy on the part of both the trainer and trainee. If the aim of training is to effect generalization, the practical limitations of the task analysis approach must be taken into consideration (Brown & DeLoache, 1977).

As we regard detailed task analyses of all possible transfer tasks as practically unfeasible, we must offer something in exchange, or at least a method of postponing or circumventing such time consuming efforts. Our criterion for a suitable test of transfer (Brown et al., 1977) is that those persons who would spontaneously adopt the trained strategy on a pretest, would also attempt to use it on the class of tasks used for transfer. One could obtain this information in several ways. For example, consider the use of cumulative rehearsal. One could ask successful and spontaneous rehearsers where and why they would think to use the strategy. Consideration of a series of such protocols should reveal prototypic rehearsal situations where almost anyone would rehearse, near cases, where there would be some disagreement concerning the suitability of rehearsal, and far cases, where no one who knew anything about rehearsal mechanisms would attempt it. The second method of obtaining the same information would be to devise a battery of tasks (prototypical instances, near and far cases) and observe when and where spontaneous producers use the strategy. Finally, within any study, a method of obtaining the desired information would be to consider the posttest generalization performance of those subjects who performed well on the pretest.

This third approach was adopted in the Brown, et al.(1977) study of span estimation (see section III. E. 2.). Originally realistic children performed well on all generalization tests, indicating their understanding of the task demands and their own ability. But trained realistic children did not perform well on the generalization tests, indicating the limitations of training (see Tables 15 and 16). Although it could be argued that the children efficient on the pretest differed from the other children on some underlying cognitive factor related to good performance on both the pretests and the generalization tasks, this is irrelevant. If the aim of training is to improve performance to match those who perform well, both in performance on the training task and in terms of general understanding, then the standards set by the originally efficient subjects are the obvious criteria of successful training.

From our point of view, the aim of training is not to get children to perform more like adults on a single task but to get them to think more like adults in a range of similar situations. If this is the desired goal then why not train (a) generalization, or (b) skills which could conceivably be general enough to fit a variety of situations? We know of no studies where, far from attempting to train generalization, the experimenter has even hinted that this is the name of the game. The impression is that the child in an experiment of this kind is the enemy, rather than the ally, in the instructional approach. Granted that as mature learners generalize spontaneously, it is interesting to point out that immature trainees do not; however, the next step is to help the less efficient by hinting that they should; or, better yet, attempt direct instruction in generalization.

Such training must go hand in hand with specific rule learning, otherwise we would have come full circle in the Butterfield and Belmont (1977) and Brown (1974) controversy. Once we have trained mastery of a mnemonic skill in terms of the first two criteria, use and maintenance of the strategy, would it not be possible to intervene with some specific generalization training? For example, one could tell the child that the trained behavior could help him on a variety of similar tasks and that the trick is to know which ones. The child could then be exposed to a variety of prototypic tasks and the utility of the strategy in such situations demonstrated. At that point, far tasks could be considered, and the reason why the trained behavior would be inappropriate could be discussed and demonstrated. Finally, the child could be presented with a generalization test containing new prototypic and far tasks and his intelligent/unintelligent application of the strategy examined. We have no idea whether such an approach would work, but given the impressive evidence of the need for explicit training for slow-learning children, it certainly seems worth the attempt.

Our final general point concerning transfer is that it might be judicious to rethink the type of skills we have attempted to train. How often does the mature memorizer rehearse? If children do not generalize a trained rehearsal strategy because they fail to see its utility, this could be a realistic appraisal of the enterprise. After all, they all tell us that they write down telephone numbers.

An alternative strategy would be to train metacognitive skills which could have broad generality across a variety of problem-solving situations. It was with this point in mind that we chose to organize the literature review with the headings of checking, planning, asking questions, self-testing and monitoring. These skills are transsituational. Perhaps it would be possible to train the child to stop and think before attempting a problem, to ask questions of himself and others to determine if he recognizes the problem, to check his solutions against reality by asking not "is it right" but "is it reasonable", to monitor his attempts to learn to see if they are working or are worth the effort. We appreciate that there are enormous problems associated with these suggestions. But, in the complete absence of data, we have no means of knowing whether such intervention would measurably improve memorial knowledge in the developmentally young. In view of the past dismal failures to induce generalization, however, we believe it would be worth the time and effort involved.

G. Training Limitations

A general point concerning training studies is that one must address the problem of limitations on the effects of training imposed by youth, lack of experience or low intelligence. The problem of intelligence and how to define it is a difficult one, and we will consider some methodological and philosophical problems of comparative research in the next section. But for the purposes of the following argument, we adopt the obvious position that, irrespective of the cause(s), individuals are not all equal in terms of their adaptation to the demands of schools and testing situations. In the case of educable retarded children it is just this lack of adaptation which has singled them out for special notice in the schools and intensive training in laboratories. To clarify our position, we must give a definition of intelligence or capacity limitations as we use the terms, for we believe that the current controversy over developmentally imposed "capacity" or "structural" limitations is generated to a large extent by the lack of explicit definition of the terms used (Chi, 1976). Possibly the dominant reason why discussions of developmental changes in capacity are often irrational and confusing is because the key terms are used loosely, interchangeably and often inappropriately. To understand such discussions, it is absolutely necessary to have a clear understanding of the underlying metaphor; not only is this rarely stated explicitly, but some authors appear to have no consistent metaphor. We cannot enter the capacity-no capacity limitation argument here but refer the reader to recent papers by Chi (1976) and Huttenlocher and Burke (1976).

To make explicit our position, the bias is toward a definition of intelligence based on executive functioning. To recapitulate, consider the range of responsibilities attributed to the executive in modern memory theories. The efficient executive is imbued with the capacity to undertake the complex coordination of routine selection, application and control. Its duty is to monitor, check and evaluate the chosen routine(s) against some criteria of effectiveness and to make inferences concerning the existing state of knowledge and the match between that knowledge and the desired goal. The executive must also estimate the probability that the goal can be reached by the methods available to the system. The characteristic features of the executive are just those that we have proposed as subjects for training: checking, planning, monitoring, etc. But this, in effect means that we want to train efficient thinking. Thinking efficiently is a good definition of intelligence.

In this context consider how intelligence is defined when the thinker is a machine. The similarity of the problems faced by those who wish to define intelligent operations either in the developmentally immature or in machines is quite striking. Moore and Newell (1974, pp. 203-204) define the essence of machine intelligence by two criteria. First, "S understands K if S uses K whenever appropriate." The distinction is between knowledge and the understanding of that knowledge. Immature thinkers fail to meet this criterion on our laboratory tasks, for this is the problem of maintenance and generalization.

The ability to use programs appropriately is the essence of machine intelligence; it is also a reasonable definition of human intelligence. It is the appropriate use of a skill that defines intelligent behavior, not adequate performance of that skill in a trained situation. The executive decision to employ the activity must be self-generated. If the routine is selected by an external agent (teacher, experimenter, etc.), he is the intelligent actor, not the child. Therefore, we believe that it does matter who acts as the executive. Although it may be "unimportant who makes the executive decision" (Belmont & Butterfield, 1977) if the object is to train improved performance on a specific task, it is vitally important who makes the decision if the aim is improved thinking; S must use K appropriately on his own volition.

Moore and Newell (1974, p. 204) give as a further consideration for evaluating machine intelligence the extent of the ability to use knowledge appropriately. "Understanding can be partial, both in extent (the class of appropriate situations in which the knowledge is used) and in immediacy (the time it takes before understanding can be exhibited)." These criteria are similar to the Resnick and Glaser's (1976) definition of human intelligence as the speed and efficiency of learning things important to one's environment. Thus, one might consider the efficiency of training in this light. How quickly and efficiently do children respond to training? And, how efficiently do they transfer the information, where efficiency is measured in terms of extent (broad generalization) and immediacy (without additionally prompting or training)? We would like to argue that if reasonable attempts to achieve generalization fail, even when the transfer tasks are appropriate (prototypic) and there have been explicit instructions concerning generalization, then a developmental limitation has been demonstrated, one which we would regard as a reasonable illustration of an intellectual limitation.

Resnick and Glaser (1976) also argue that intelligence is the ability to learn in the absence of direct or complete instruction. Therefore, if generalization could only be obtained by training it directly, we would not necessarily regard this success as a disaffirmation of an intellectual limitation position. For if it can be achieved only with direct training, such generalization fails to meet the criterion of "in the absence of complete instruction." Furthermore, there is no reason to suppose that if transfer can be achieved in one domain only following detailed instruction, it would occur spontaneously in another.

We introduce these points because we have been cited as favoring an "anti-structuralism" position (Belmont & Butterfield, 1977). That is, because of the emphasis in prior work on strategy training, it has been assumed that our position is that there are no "capacity" differences between the developmentally young and more mature thinkers, performance differences are attributed to inappropraate use (or no use at all) of mnemonic strategies and such strategy use can be trained. This argument rests on the definition of the term capacity. We would like to reaffirm the position that recourse to an unspecified "capacity limitation" when a particular training on a specific task fails, is difficult to defend logically and is premature until alternative training methods have been examined (Brown, 1974). We also know of no compelling evidence that capacity differences in terms of the architecture of the system (e.g., STM), amount of space in the architectural units (e.g., the number of slots in STM),or in terms of durability of information in these systems, differentiates the immature from the adult thinker (Belmont, 1972; Belmont & Butterfield, 1969; Brown, 1974; Chi, 1976; Wickelgren, 1975).

This is not to say, however, that the developmentally young are not handicapped by limitations to their central processing resources, limitations which cannot be attributed to a simple notion of capacity. The effects of an impoverished knowledge base (LTM) alone can account for many of the reported developmental difficulties. Long-term memory is the repository of rules, strategies, and operations which can be used to make more efficient use of a limited capacity system. In addition, the child's knowledge base is deficient in at least three ways: (a) the amount of information it contains, (b) the organization and internal coherence of that information, and (c) the number of available routes by which it can be reached. These differences impose several limitations on the child's information processing abilities, even in such simple situations as reading information from the icon or maintaining information in STM (Chi, 1975, 1976). Such basic cognitive processes as ease of retrievability, and speed of encoding, naming, and recognition are all influenced by restrictions imposed by an impoverished knowledge base.

The limitations to the knowledge base are clearly not susceptible to relatively brief training and intervention, no matter how ingenious. One cannot undertake to enrich the knowledge base in three, or even 23 easy lessons. Of course, such "structural" limitations are not fixed, as age and experience will lead to reorganization and enrichment of the knowledge base, an enrichment and reorganization program that continues throughout the life span (Brown, 1975). Intervention could take the form of exposing impoverished children to a richer array of experiences, the rationale behind many headstart programs, but it is difficult to imagine detailed training programs to effect this end. Training itself is limited by the restrictions imposed by the current state of the knowledge base (Brown, 1975; Siegler, 1976; Klahr & Siegler, in press).

In addition, there are limitations placed on the effects of training due to low intelligence. We believe that both the extent of training needed to effect adequate performance and the efficiency of training in terms of extent and immediacy of transfer are indices of intelligence. Although the cultural relativity of both the task and training must undergo careful scrutiny before such conclusions can be reached (see Section V.).

A further characteristic of intelligence is that not only can old skills be used appropriately in new places but they can be remodelled creatively to meet new task demands. Furthermore, new solutions can be invented on the basis of old knowledge alone. Resnick and Glaser (1976) have provided a recent discussion of the problem of intelligence and invention, and we do not want to reiterate it here. The point is included to demonstrate how weak a criterion of intelligent thinking is our demand for spontaneous generalization of a learned skill to prototypical transfer tasks.

The entire preceding section is in some ways trivial. First it is obvious that there are functional differences between the developmentally young and mature problem solvers, for if there were not, intervention would not be required. Second, and more important, the position one assumes concerning the cause, type, or susceptibility to remediation of such developmental differences has little effect on the practical problem of training. The difference of opinion is theoretical not practical, descriptive not prescriptive. We believe as strongly as anyone that no attempt should be spared to provide intensive intervention to improve problem-solving abilities, particularly in slow learners. One major responsibility of an instructional psychologist is to devise increasingly ingenious training programs to induce enhanced performance. Furthermore, we have always been, and remain, optimistic concerning the success of well-designed training, and the real practical significance of such success in terms of worthwhile improvements in performance. We included this section because we believe there are limitations on the effectiveness of training and therefore would like to disassociate ourselves from an extreme anti-structuralism position.

V. Memory, Intelligence and Instruction

A major focus of our research efforts in the area of memory development has been an emphasis on the trainable, particularly with reference to slow-learning children. Although the research is "basic" in that it is conducted in laboratory settings to test hypotheses of theoretical interest, the underlying rationale has always been that information of practical significance would be forthcoming. Although we have neither the skill nor professional training to devise detailed curricula for instructive purposes, we hope that some of our training techniques could be implemented in instructional settings. In this section we will first consider formal instruction, the schools, and their influence on metacognitive development. We will then examine the particular problems of the disadvantaged child in school settings. Finally we will indicate the type of instruction which might prove practical and feasible.

A. The Effects of Formal Schooling: Intercultural Comparisons

It is interesting to note that the period of development when the major changes in memorization skills occur, from the first emergence of the child's awareness of himself as an active agent in knowing, to the establishment of the complex executive functions exhibited (sometimes) by high school and college students, coincides exactly with the period of formal education in most Western societies. Does this suggest that formal education is in some way implicated, that we have a case of educational rather than maturational development? The only meaningful way to consider such a question is by reference to cultures where the degree of formal schooling and chronological age are not hopelessly confounded as they are in Euro-America. A cursory review of the cross-cultural literature suggests some pertinent findings concerning the cultural relativity of many of the skills we have discussed in this chapter. Such a review also directs our attention to some basic philosophical and methodological problems associated with the type of experimentation employed by psychologists to gather comparative data, and to the validity of the interpretations given to such data.

Consider first some cross-culture psychological evidence concerning the development of memorization efficiency. One of the consistent differences between schooled and unschooled populations rests in the ability to deal with the kinds of mnemonic skills for deliberate memorizing we have discussed in this chapter. Several years of formal schooling seem to be necessary before the emergence of spontaneous attempts to organize, rehearse, or categorize taxonomically for the purposes of rote remembering. In addition to a general lack of what we regard as routine memorization skills, unschooled populations differ in terms of their ability to transfer problem solutions readily across laboratory tasks. Scribner & Cole (1973) suggest that one cognitive characteristic of unschooled populations is that they tend to treat the usual laboratory learning and memory tasks as independent, each as a new problem. In short there appears to be a conspicuous absence of learning to learn. Schooled populations, however, show a marked tendency to treat such problems as instances of a general class. The application of common operations and rules to a universe of similar laboratory tasks appears to be an outcome of formal schooling.

Similar differences between schooled and unschooled populations have been found when the experimental task involves certain metalinguistic abilities. For example, children experience difficulty in dealing with decontextualized language. Osherson and Markman (1975) presented young children problems of the form: "either it is raining outside or it is not," or the "chip (hidden) in my hand is blue or it is not blue." The children indiscriminately sought empirical support for the truth value of the statements; they did not recognize the non-empirical nature of the simple contradictions, or at least were unwilling to evaluate these sentences in the absence of empirical evidence. A similar example of the need for empirical support to evaluate language comes from Scribner's (1976a) studies of comprehension of classical syllogisms among schooled and unschooled Kpelle villagers. Given problems such as "All Kpelle men are rice farmers. Mr. Smith (Western name) is not a rice farmer. Is he a Kpelle man?", unschooled villagers refused to consider the problem if they had not met Mr. Smith. They did not appear to grasp the fact that the task involved logical implications determined solely by the structural relations between the stated propositions, independent of their factual status. Again, on the basis of the limited evidence it would appear that certain forms of logical thinking in response to traditional academic problem-solving situations, far from being the natural outcome of maturation, are very much dependent on the intervention of formal schooling.

Piagetian experiments conducted cross-culturally again support the idea that the degree of formal schooling is an important factor in determining progression to higher levels of abstract thought (Dasen, 1972). In keeping with the other psychological evidence, Lloyd (1972) suggests that the emergence of formal operations, as defined by the Piagetian system, depends haavily on Western-type schooling and that "this is hardly surprising since the structures of formal thought, the propositional calculus, and the mathematic four group are products of Western thinking. Their universality, as the goal of mature cognitive development, is an open question" (Lloyd, 1972, p.137) In support of this position Piaget (1972) himself has recently suggested that under some cultural conditions formal propositional thinking may not emerge at all.

Finally, Olson (1976, 1977) and Bruner (1972) have suggested that the move from an oral to a literate culture imposes fundamental changes on the ways of knowing of people. A strong case is made that the type of cognitive activities perfected by a culture are determined by the socio-economic milieu (Luria, 1971) and that the invention of a phonetic writing system had profound historical consequences on the nature of human thought. We cannot give a full discussion here but would like to concentrate on three interconnected emphases of a literate tradition which are fostered by Western-type schooling, decontextualization and formalization of the language, an emphasis on the logical rather than the rhetorical function of language, and an emphasis on the general context-free rule rather than the particular experience.

Briefly, an oral tradition depends heavily upon a particular form of thinking biased by the limitations of auditory memory. The system is well-equipped to deal wit proverbs, riddles, adages, etc. but

> neither principles nor laws nor formulas are amenable to a syntax which is orally memorizable. But persons and events that act or happen are amenable. Orally memorized verse (including the epics) is couched in the contingent. It deals in a panorama of happenings not a program of principles. (Havelock, 1971, p.51)

Oral memory is biased in the direction of rhymes, riddles, proverbs, metaphors, and wise and witty sayings. Written messages, however, are uniquely adapted to an analysis of the implications and entailments of statements. When a child learns to write the dependence on context, on empirical support to validate statements, must be overcome. He must learn to write things which a reader, removed from him in time and space, and unable to ask questions, can understand. He must learn to comprehend and produce a written language which is explicit and relatively context-free.[4] Beyond mere literacy lies formal definition and scientific writing which not only depend on context-free explicit language but also demand formal definitions of terms and the analysis of the implications of propositions.

Olson (1976, 1977) has argued that the literate tradition has specialized the language to serve a logical function at the expense of the social, rhetorical function. The rhetorical function of language involves social, authoritative and context-bound communication. The child in a literate society must come to single out the logical aspects of statements from the authority maintaining social functions.

Bruner and Olson believe that the emphasis on the formal logical function of language in literate societies affects the ways of knowing of the people and biases the definition of intelligence in these societies and the growing body of cross-cultural literature supports this difference hypothesis. Formal schooling in a literate tradition influences the course of cognitive growth, relatively unschooled populations display different patterns of cognitive activities than do the products of formal schooling. Does this mean that one can accept a defect hypothesis: that unschooled populations are less intelligent than the schooled? After all, the tasks used to detect a difference are those associated with intelligence in our society.

Such an interpretation of the existing data is illegitimate. First, as modes of thinking and ways of knowing are molded by cultural context, one cannot sensibly specify intelligence outside of the culture with which it is interacting. If we accept as one definition of intelligence, adaptation to real-life problems, quite different performances would be considered adaptive in different cultures. It is therefore, an invalid inference to suggest that unschooled populations are less intelligent because they do not perform in a fashion comparable to Western children on a particular laboratory task or IQ test item; it is not reasonable to discuss intelligence (adaptation) without reference to the culture to which the developing child must adapt.

Cole and Scribner have provided a rich source of evidence to support a difference rather than a defect interpretation of cross-cultural findings and they demonstrate that logical thinking, efficient communication, elaborate mnemonics and generalization are features of thought in both traditional and schooled societies. It is the form that these aspects of cognition take, not their presence or absence, that distinguish schooled and unschooled populations. For example, Scribner (1976a) gives many illustrations of "wrong" answers given by unschooled Kpelle to the totally unfamiliar logical syllogism problems. Nevertheless, the wrong answers contained elegant examples of chains of reasoning which followed logically from the evidence used by the subjects. Consider also this fine example of Kpelle cognition. Kpelle villagers were asked to group together a set of items in the way that made Kpelle sense--they grouped by functional relationships. Next the villagers were asked how a stupid person might group them--they produced perfect taxonomic groupings. Interestingly, functional groupings appear to be universally accepted but taxonomic categorization is influenced by the degree of recency of exposure to formal schooling (Denney, 1974; Overcast, Murphy, Smiley & Brown, 1975). Only taxonomic categorization is taken as a measure of higher intelligence within our society. It reflects our cultural bias that we call one activity more "intelligent" than the other. In a review of the cross-cultural studies on cognitive development, Lloyd concluded with the statement

> men are fundamentally similar in their intellectual skills but these skills are differentially realized in culturally diverse settings (and) no one setting should be acclaimed as superior (Lloyd, 1972, p. 153).

Michael Cole and his associates have pointed out that anthropologists have, indeed, long advocated the similarity rather than the divergence of human intelligence in different cultural groups; it is psychologists who emphasize the difference. Anthropologists' tools consisting mainly of ethnographic description of naturally occurring behaviors, are different from the tests and experiments imported by psychologists, and anthropologists object to the traditional laboratory task used by psychologists, not only on the obvious grounds that the experimental materials, tasks and procedures developed in Western societies are ethnocentric and culturally biased, but because the experiment itself as a context for eliciting evidence of cognition has no ecological validity in the cultures to which it has been transported (Scribner, 1976b).

Both Lloyd (1972) and Cole and Scribner (1975) believe that the traditional laboratory tasks can be used in cross-cultural research when due caution is paid to the interpretation of the outcome.

> evidence of cultural difference in response to a particular task (should) become the starting point rather than the goal of cross-cultural research, and performance on a task should be scrutinized to determine whether it is a meaningful response or attempt to satisfy the arbitrary whim of an alien investigator (Lloyd, 1972, p. 153).

Cole and Scribner suggest a three-pronged research strategy for investigating cognitive development comparatively. First, one should investigate the subject's understanding of the experiment and his role as the subject. In light of the Kpelle example of clever vs. stupid answers, this is a vital point. Indeed Campbell (1964) suggests that without compelling evidence to the contrary, we should regard any gross differences found in comparative research as failures of communication between the experimenter and his subject. The second research strategy is to "experiment with the experiment" i.e., instead of using one fixed paradigm in many different cultures, the experimenter should work with many different variations of a single paradigm within one culture. An excellent example of this approach is the work of Cole and his colleagues (Cole & Scribner, 1977) concerning free recall in the Kpelle. The third strategy is to investigate the same process in a range of situations including the naturally occurring contexts of the culture, and also in experimental and quasi-experimental settings (Campbell & Stanley, 1966).

The basic theme is a call for an interweaving of experimental and ethnographic research to investigate a particular cognitive activity in a range of situations from the naturally occurring to the experimental. We will argue later that such a strategy is ideally suited for comparative research when the groups differ not in terms of national origin or degree of formal schooling, but in terms of age or school success within a society. Similarly, we will argue that the same caution advised for the interpretations of group differences on traditional laboratory tasks or IQ test items be extended when interpretation is made concerning the developmentally immature and their "normal" counterparts.

B. The Socio-Historical Context: Intra-cultural Comparisons

The main emphasis of the cross-cultural, psycho-ethnographic approach expoused by Cole and Scribner is that it is difficult if not impossible to consider any psychological process separated from the context in and the content on which it must operate

> The psychologist examining any mental mechanism is of necessity examining a mechanism normally operating with material given in society and culture and he cannot get away from such "living contents" even in the artificial isolation of an experiment. Similarly, if anthropologists are concerned with how "living contents" come into existence and change over history, they need to understand what operations (processes) individuals bring to the material that is culturally given (Cole & Scribner, 1975, p.261).

A similar emphasis on studying cognitive growth within a society in terms of socio-historical context has been the underlying philosophy of Soviet investigation into memory development across the life span. In a recent review of Soviet investigations, Meacham (1977) points out that there are three major themes permeating the Soviet approach. We would like to focus on two of these themes. First, the individual's motives and activities interact with content to determine what will be remembered. Second, the particular cognitive activities shown by individuals are in large measure molded by cultural and historical conditions. We would like to point out the strong similarity in position between the Soviet-dialectic approach (Riegel, 1976) and the psycho-ethnographic position adopted by Cole, a similarity which is perhaps predictable given Cole's long interest in Soviet psychology.

The main thrust of the argument is to alert us to the fact that social-ecological factors must be considered as shapers of cognitive activities within our society as well as between peoples of culturally diverse groups. We have argued elsewhere (Brown, 1975) that in order to understand memory efficiencies and weaknesses in young children, it is necessary to consider the ecological validity of traditional laboratory tasks in the light of naturally occurring situations of preschool life. The Soviets' definition of "leading activities" (Meacham, 1977) which dominate the organization of cognition at any one stage of development is particularly relevant to this point. Actions are organized around leading activities which change ontogenetically. The sequence of leading activities depends upon the specific social and historical conditions of the developing child. Thus Soviet research in memory has as its main focus the development of cognitive activities in response to cultural forces and there is a heavy concentration on memorization subordinated to a purpose, a leading activity of cultural relevance to the individual (e.g., practical settings rather than laboratory tasks, play activities for small children, operating a telephone switchboard for adults). The focus is on the motivational and cultural historical context of remembering and relies predominantly on observational and descriptive techniques rather than experimental control. In contrast, Kvale (1975) has argued that nondialectic research in memory development has focused on meaningless materials and has ignored the fact that remembering always occurs within contexts and on contents. The contexts and contents powerfully influence memorization styles.

In summary, cognitive activities develop and change within a socio-historical cultural context and the nature of these acculturation processes influence the leading activities, motives, focus and types of cognitive activity displayed by the individual. It is therefore profitable to view the memory abilities of the developing child in relation to the ecology of childhood. Furthermore, in order to assess the type of processes typical of an individual at any one stage of development, it is necessary to consider factors other than individual performance on artificially contrived laboratory tasks or IQ tests. The particular processes of interest should be considered in a variety of situations, including the naturally occurring leading activities of childhood (Istomina, 1975).

C. The School as a Cultural Context

As formal schooling has such a powerful effect on the course of cognitive growth, it might prove instructive to think of schools as a mini-culture within which certain specialized sets of skills are emphasized and refined. Techniques and qualities of memory are no less influenced by the school experience than are any other cognitive activities. It is in the context of formal schooling that many of the changes we have discussed take place, changes in the variety of available mnemonics, and in the knowledge one has concerning one's own competence and fallibility as a memorizer of school materials. This should not be surprising as schools represent the major cultural institution in technological societies where remembering as a distinct activity or specialized skill, in and for itself, in isolation from possible applications, is routinely undertaken. Outside the school setting, in unschooled populations, includin that of the preschool child, such activities are rarely, if ever, encountered (Brown, 1975). Deliberate remembering as an end in itself rather than as a method of achieving a meaningful goal is very much a school inspired activity.

Therefore, one might expect formal schooling to result in the formulation and refinement of a specified set of skills specifically tailored to the needs of academic learning. The familiar memory strategies discussed here are the outcome of a specialized cultural force, schools, and not the inevitable results of human maturatior Adaption to a habitat forges the direction of cognitive development; schools are only one such habitat, and in historical perspective, a very recent development at that. Outside of school settings other perfectly valid sets of cognitive activities may characterize the course of cognitive development.

Consider just one example of a "naturally occurring" strategy, the reliance placed on external aids to support mnemonic performance. Flavell and his co-workers have shown many examples of the young child's preference for external means of memorizing real-world information. Even remembering a telephone number elicits external (writing down) rather than internal (rehearsal) storage.

> In real extralaboratory life situations, people make extensive use of external storage and retrieval resources, both human and non-human. In the outside world people take notes on things and make notes of things: they exploit the capacious and leakproof memories of books, tape-recorders, videotapes, films and computers. They get other people to help them store and retrieve information, both internally (i.e., in other peoples' heads) and externally. The real world's tasks generally have the properites of an open-book, take home exam even if the memory researchers' tasks do not (Flavell, 1976a, p.233).

Preschool children rarely if ever encounter situations which call for deliberate internal memorization of decontextualized materials (Brown, 1975). Similarly, members of traditional societies tend not to encounter such situations in everyday life and adults in our society, when removed from the school setting, rarely if ever engage in such esoteric mental activities, with the possible exception of rote memorization of a limited set of personal numbers (telephone, social security, etc.). Scribner (1976b) has argued that the ubiquitous free-recall paradigm is particularly inappropriate for cross-cultural comparison as it does not provide external cues for recall but demands that internal cues be produced to structure performance. Scribner believes that such a heavy emphasis on internal retrieval cues is largely absent from naturally occurring, everyday-life memory problems and she quotes Margaret Mead's anecdotal observation of reliance on external cues in primitive peoples.

> The Aborigines of South Australia have cultivated a type of memory in which they have to walk through the terrain which is involved in a myth in order to be able to tell a long totemic myth correctly. The stimuli which call the correct incidents to mind are outside themselves in their territory (Mead, 1964, p. 103).

The similarity to the well-known "method of loci" (Yates, 1966) is striking. Recall that the method of loci was developed to meet the needs of Roman *orators* who required techniques for remembering the sequential order of the main points of their oration. That with minimum instruction young children (Brown, 1973b) and adults (Bower, 1970) can all use such techniques effectively is a powerful testimony to the efficiency of externally cued recall.

The use of locations, settings and physical reminders (notes, string, etc.) to mediate memory is a contextual form of cued recall, situated in real-life experience and, we would argue, a predominant form of human mnemonic. The use of decontextualize internally cued mnemonics for remembering arbitrary contents, however, is a specialized form of cognitive activity not only typical of a Euro-American literate tradition but possibly a product of formal schooling itself. Such skills are not necessarily representative of basic cognitive processes.

We would argue that there is a basic universality and continuity to human conceptual development based on forms of knowing which Nelson has referred to as scripte knowledge (see Nelson, 1977, for a full discussion). Nelson's description of a script for organizing the interaction of a number of different concepts around an action or a goal is very similar to Cole and Scribner's (1977) description of a natural type of memory concerned with personally experienced scenes or events which lend organization and predictability to the world around us. It is also similar to Havelock's (1971) characterization of the type of memory refined in oral traditions, knowledge centered around persons and events that act or happen tn meaningful contexts.

Nelson points out that context-derived event structures and scripts involving actually experienced, meaningful and repetitive sequences in space and time are the important organizing structures for young children (Nelson 1977; Nelson & Brown, in press). We believe that this may be the dominant form of knowing in both the mature in our society (Denney, 1974; Overcast et al. 1975) and unschooled young adults in other societies (Cole & Scribner, 1977). The further divorced one is from formal schooling in terms of recency or extent of the experience, the more one's thinking is dominated by scripts based on real-life actions. Although based on context-constrained, actually experienced happenings, the scripts of everyday knowing are generative. General rules are "abstracted" from the particular repetitive experiences to allow interpretation of the novel, prediction of the familiar and to provide an organizational structure for a personal universe.

Thus, we would argue that there is a fundamental universality to human conceptual development and the basic way of knowing consists of the formation and refinement of increasingly richer event structures or scripts (Nelson, 1977), centered around action sequences which recur in personally experienced contexts. Later emerging, relatively context-free organization or rules are in addition to and not a replacement for the basic spatio-temporal scripts of knowing. Specifically, specialized elaborate skills for different kinds of remembering are developed in different contexts with differing leading activities (Meacham, 1977), for example, study skills for remembering texts in schools in our society vs. oral mnemonics for the transmission of epic poems (Colby & Cole, 1973) or for retaining totemic names for debating (Bateson, 1958) in traditional societies. There is considerable evidence that even in the absence of explicit instruction, the requirement of formal schooling determines the direction of mnemonic development in Western societies. The ability to comprehend and retain information couched in increasingly decontextualized and formalized language presented in texts is the leading activity in schools. Thus, the development of specialized cognitive activities to achieve this end must be seen in the sociohistorical context of schooling in advanced technological societies and not as a reflection of the natural and product of himan cognitive growth.

D. Schools and the Disadvantaged Child

Each culture invents its own set of techniques for refining basic cognitive resources to meet a specialized need. Within our society it is in the context of schools, particularly the later grades, that great emphasis is placed on decontextualized skills of knowing. As Bruner and Olson have pointed out, "whether for reasons of economy or effectiveness, schools have settled on teaching/learning out of the context of action and through media that are primarily symbolic and decontextualized" (Bruner & Olson, 1977 , ms. p. 1). They continue in a latter part of the manuscript,

> Progressively aided by the decontextualized atmosphere of school, the literate child comes to manage statements as propositions with entailments, to recognize that a statement is true, not because it is empirically plausible or has been experienced, but simply because it is entailed by another proposition also in the text. *If not all achieve this skill* (italics mine), at least it is held up as an ideal (Bruner & Olson, 1977, p.21).

Although one might argue with the assumption that the modes of thinking of middle-class Western college students should be a goal for cognitive growth in all members of our society (Lloyd, 1972), it is certainly true that academic success in our schools, and to some extent, economic success in our society depend on achieving a reasonable degree of ease in this domain. Children are expected to make the transition from the context-bound, experientially-based, play-centered culture of preschool life, to the context-free, impersonal, learning-for-learnings-sake atmospheres of the schools. Some make the transition, others do not. Many that do not can be termed disadvantaged in terms of their preparation for school. Many that do not may become labelled as retarded, if the transition is unduly troublesome.

Consider briefly what we know about disadvantaged children which might render the transition more difficult for them than for the middle-class child. Ignoring obvious problems such as facing a new language, either in terms of a different dialect or a second language, the disadvantaged child is hampered by a restricted language code (Bernstein, 1971) which favors the context-bound, social, rhetorical functions of language (Olson, 1976) rather than the context-free explicit communicative mode demanded in school. Furthermore, we know that very early in his school career, the disadvantaged child has difficulty dealing with problem solutions divorced from empirical support, and difficulty generating aids, mnemonics, search strategies, etc., to enhance deliberate learning. He needs explicit instruction in developing these skills and even then may fail to generalize the effects of training to similar classes of activity. Perhaps because of these problems, his metacognitive development is impaired. Simply stated, without considerable experience and success with this type of problem-solving activity, the child can hardly be expected to exert control (Brown & DeLoache, 1977).

Perhaps there is a more basic problem. Early failure experiences can seriously erode the child's self-concept. He may have no reason to believe in himself as an active agent in knowing what there is to know in school. If he has no expectations concerning his ability to control school performance, this would surely vitiate any attempts to achieve such control. Learned helplessness (Dweck, 1976) can be acquired early. The child's objective knowledge of his own cognitive processes is obviously contaminated by his feelings of competence. Competence within a school setting may not be expected by many disadvantaged children, and particularly not by those singled out for "special" education in response to their supposed incompetence.

Bruner (1972) has pointed out that schools as an institution are separated from both the early play activities thought suitable for childhood and even from most vocational activities demanded of adults. For example, in primitive societies children learn by imitating adult models, initially in the context of play activity (mock hunting, weaving, cooking, ritualistic practices, etc.). The transition from play activities to the real adult occupation (i.e., play hunting to hunting) is gradual; there is no sharp division between the early exploratory play of childhood and the vocational pursuits of the adult. In our society schools intercede between the two worlds but they do not forge a necessary link. Not only is entering into the school system an alienation process (play activities are discouraged, learning by listening and reading rather than acting is encouraged) but the necessary link with the exit into adult society is also less than clear.

> School, separated from work which itself has grown difficult to understand, becomes its own world. As McLuhan (1966) insists, it becomes a medium and has its own message, regardless of what is taught. The message is its irrelevance to work, to adult life. For those who wish to pursue knowledge for its own sake, this is not upsetting. But for those who do not or cannot, school provides no guide--only knowledge, the relevance of which is clear neither to student nor to teachers. These are the conditions for alienation and confusion (Bruner, 1972, p. 703).

If schools do not relate to the real-life experiences of play or work activity which the child encounters daily, it is not surprising that the enterprises valued in the classroom do not "make sense" to many children. If lessons are not meant to "make sense" why should the child check his performance against criteria of the plausible or sensible? This problem of alienation was seen even in Holt's (1964) middle-class, above-average children (see section III, D.2.) but it is much more of a problem for the disadvantaged child for whom acculturation to a school setting demands a more radical shift from preschool conditions. "Playing the game of school" (Anderson, 1977), learning a script for how to behave in school, may never be acquired by such children unless some form of intervention is attempted.

Certain facts exist, all children do not make the transition to schooling with equal ease, some never make the transition and are marked for school failure. Whether this is due to biological, or socio-economic reasons, or any combination offactors is irrelevant. The next question is, given the esoteric nature of many school practices, should all children be expected to conform to the standards set? Although the answer must surely be negative the implications of accepting that position, in terms of selecting those that will enter higher level academic programs and those that will not, are wide ranging, controversial, and cannot concern us here. Rather we assume the position that it is beneficial for as many children as possible to acquire some facility with traditional school skills; therefore intervention should be offered to all who need help. Schools come into existence and are the way they are because they meet the needs of a technological society. It is unlikely, therefore, that schools, and the skills valued in schools, will change radically. Thus we must prepare as many children as possible to meet the demands of schools as they exist today. This means tailoring teaching techniques for, and expending resources on, those who experience difficulty with the transition.

It is for these reasons that we have been increasingly concerned with educable retarded children, and more recently, children at risk for retardation. Many educable children suffer from school disease; they are only singled out officially as retarded or slow in the school setting. Prior to school they either experience no difficulty or their difficulties go undetected. After school, the majority are again absorbed within the community (Edgerton, 1967). Only during the school years are they segregated. If they can be helped to achieve minimal success with school tasks the benefits would be enormous; they would avoid being branded in school as "special," together with the concomitant loss of their own feelings of competence.

An implicit defect theory often appears to guide our approach to those already singled out for special classes. Such children are characterized as those who do not learn quickly and are difficult to train. But these conclusions often are derived from a consideration of data collected on isolated laboratory tasks, and IQ test items, using procedures and materials unfamiliar to the child. We would like to argue that the same caution demanded by Cole and Scribner (1975) for cross-cultural comparisons of cognitive processes should also be extended to the interpretation of intra-cultural comparative data. That our subjects do not generalize a cumulative rehearsal strategy does not mean that they cannot generalize. They clearly can and do transfer knowledge flexibly in real-life situations. The need for multiple-observations of a particular phenomenon, demanded in cross-cultural research, is no less apparent in any research program which seeks to make comparisons between groups that differ in terms of age, nationality, ethnicity, IQ score,etc. Therefore we strongly endorse Cole and Scribner's (1975) three-point plan for comparative research: (a) investigate the subject's understanding of the experiment, (b) experiment with the experiment, and (c) investigate the same process in a range of situations, the naturally occurring, quasi-experimental and the experimental. We know of no research program concerned with cognitive development in slow-learning children that meets these criteria.

The learning of isolated materials for a purpose neither understood nor appreciated is not an easy task for the skilled, and far less so for the novice. If the slow learning child comes to view this as the leading activity of school, he is doomed to failure. The aim should be to "recontextualize" (Anderson, 1977) early school experiences, to breathe meaning into school activities in order to alleviate the transition difficulties of the disadvantged child.

The distinction described earlier, between oral and literate traditions may be helpful in suggesting new ways of approaching the school problems of the disadvantaged child. Rather than thinking of slow-learning children as lacking certain skills, it might prove profitable to reverse the emphasis and concentrate on the skills they do possess, those of an oral tradition. If we are searching for competencies to harness in the service of school settings, the competencies of the oral tradition could be a good place to start. Educable retarded children are adept at remembering places, people, and things experienced in their daily life. They have elaborate scripts for coping with their home and street environments. They show an amazing ability to recall lyrics from popular songs (retained over an equally amazing time period), baseball scores, the top twenty songs, and the times of television programs, etc. Thus we would argue that the transition to formal schooling might be made easier for disadvantaged children if (a) the emphasis was placed on their strengths in the skills of an oral tradition rather than their weakness in the not yet acquired literate ones, (b) game-like learning by apprenticeship systems (watching and doing) were maintained for as long as possible, and (c) careful attention was paid to the content and context of any desired activity in terms of its interest and relevance to the child's knowledge of naturally-occurring activities.

Such general exhortations are easy to make but hard to implement. But if they are to be taken seriously, practical step-by-step descriptions of how one might implement a single program are needed at the very least. From the perspective of an experimental psychologist, specifying the stages in a research program would provide the necessary instantiation and we will try to do that here. However, we would like to emphasize that the program has as an underlying princple, the provision of basic information of practical value, that is, it could and maybe should be directly implemented in instructional settings.

Consider the progress to date of our attempts in training mnemonic and metamnemonic skills in educable children. We know that training specific traditional mnemonic routines is not a promising avenue to pursue as the benefits are restricted to a very small range of situations. Training such skills in meaningful contexts, together with explicit instruction concerning the reasons why such skills can be useful looks more promising and is currently underway in our laboratory (see section IV. F.).

A more fundamental change in approach is that we believe that serious concern should be given to the skills that are the subject of training. The type of cognitive activity selected for intensive intervention should have certain properties; (a) it should have great transsituational applicability, (b) it should be readily seen by the child to be a reasonable activity that works, (c) it should have some counterpart in real-life experiences, and (d) its component processes should be well understood so that effective training techniques can be devised. Our bias directs us to a subset of metacognitive activities which we feel admirably fit the prescription, checking, monitoring, and reality testing, etc. This is, of course, still too ambitious and we would advocate the selection of a few basic skills for intensive study. The ones we have chosen can be subsumed under the general heading, self-interrogation.

The eventual aim is to train the child to think dialectically, in the sense of the Socratic teaching method. In the Socratic method, the teacher constantly questions the students' basic assumptions and premises, plays the devil's advocate, and probes weak areas, using such techniques as invidious generalizations and counter-example (Anderson, 1977; Collins, 1977). The desired end-product is that the student will come to perform the teacher's functions for himself via self-interrogation. Although the skills described by Collins are obviously not directly applicable to young slow-learning children, the basic principles underlying the approach are. We would start at the very simple level of teaching the child to self-interrogate when faced with a certain class of problems (instructions, math problems, a laboratory task, etc.). The type of self-interrogation that might work would be something like a routine set of n questions to ask oneself before proceeding, e.g., (a) stop and think! (b) do I know what to do (i.e., understand the instruction, both explicit and implicit)? (c) is there anything more I need to know before I can begin? and (d) is there anything I already know that will help me (i.e., is this problem in any way like one I have done before)?

We are currently attempting to train educable children to follow both verbal and written instructions and to perform a variety of simple prose comprehension tasks, all in the context of a meaningful activity, like assembling a toy or following a recipe. In the course of these activities, they deliberately and overtly pass through a self-interrogation routine like the one described above. We believe that devising simple systems for eliciting self-awareness and conscious control over one's own activities is an important form of training because it is a desirable end-product in its own right, it should have transsituational applicability and it should improve both the child's cognitive and metacognitive skills and his feelings of personal competence.

VI. Summary

The principal theme of this chapter has been the development of certain metacognitive skills which are indicative of efficient problem-solving in a variety of situations, whether experimental, educational, or naturally occurring. We believe the distinction between knowledge and the understanding of that knowledge to be a valid and important distinction with great heuristic power for those interested in cognitive development. The emphasis in this chapter has been on the executive processes which underlie the cognitive products of the child; the executive processes of modern cognitive theory---predicting, planning, checking and monitoring. We suggest that these are the basic characteristics of efficient thinking in a wide range of learning situations.

It is a reflection of the state of the art that the majority of developmental and training studies to date have been concerned with the conscious control of a few "simple" mnemonic skills for deliberate remembering. The cultural relativity of such skills was discussed both in terms of their ecological validity cross-culturally, and with reference to the school problems of educable retarded children.

One main purpose of this chapter was to emphasize the paucity of experimental studies concerned with general metacognitive skills outside of the framework of traditional memory tasks. A particularly neglected research area has been the development of efficient training programs for the developmentally young, programs that concentrate on executive functioning rather than the perfection of a specific skill. Training techniques to induce simple checking skills in those who would not introduce them spontaneously, at least in the context of school learning or traditional laboratory tasks, have not been developed. Although the problems entailed in devising such training programs cannot be overestimated, the benefits both practical and theoretical that would accrue warrant the expenditure of effort and ingenuity.

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[2] Throughout the study half the lists were categorized and half were uncategorized. This variable was included so that students would not learn that they should say a particular number, e.g. 6, when asked their span. An appropriate response would indicate a higher number for an organized list and this was found.

[3] Preliminary data suggest that successful maintenance of recall readiness was followed by generalization to a prose learning situation. This study is still underway (Brown & Campione, 1977b).

[4] Strictly speaking no message, even a written one, is truly context free in that the reader is free to disambiguate and instantiate utterances on the basis of his world knowledge. The term decontextualization is used in Olson's sense of a written message's liberation from the immediate social context for interpretation.

Table 1

The Relation of Accuracy to Confidence Judgements of Educable Retardates Concerning Recognition Choices in a Feeling of Knowing Experiment (Brown & Lawton, 1977)

Groups	Young (MA 6)	Medium (MA 8)	Old (MA 10)
N	17	15	27
sure	.54	.71	.66
not sure	.34	.34	.28
difference	.20	.37	.38

Table 2

Story List Item from Kreutzer et al. (1975)

The Proportion of Subjects Making Each Choice and Justifying Their Choice[a]

Subjects	N	Story Format			Justification	
		Easier	Harder	Other	Present	Absent
Six-Year-Olds (MA 6)						
Normal Kindergarten[b]	20	.50	.25	.25	.15	.85
Naive Educable	21	.81	.19	.00	.05	.95
Experienced Educable	40	.78	.18	.03	.20	.78
Eight-Year-Olds (MA 8)						
Normal Third Grade[b]	20	1.00	.00	.00	.70	.30
Naive Educable	28	.75	.04	.21	.04	.96
Experienced Educable	30	.80	.20	.00	.40	.60

[a] Interrater reliability .96

[b] The data for normal children are from Kreutzer et al. (1975)

Table 3

Opposites-Arbitrary Items from Kreutzer et al. (1975)

(Proportion of Subjects Making Each Choice)[a]

Subjects	N	Opposites Easier	Arbitrary Easier	Same	Adequate Justification
Six-Year-Olds (MA 6)					
Normal Kindergarten[b]	20	.30	.50	.20	.10
Naive Educable	21	.43	.57	.00	.10
Experienced Educable	40	.31	.69	.00	.12
Eight-Year-Olds (MA 8)					
Normal Third Grade[b]	20	.90	.10	.00	.65
Naive Educable	28	.57	.39	.04	.42
Experienced Educable	30	.48	.52	.00	.40

[a] Interrater reliability 100%

[b] Normal data from Kreutzer et al. (1975)

Table 4

Rote Paraphrase Items from Kreutzer et al. (1975) Questionnaire

(Proportion of Subjects Making Each Choice)[a]

Question Number		1	2	3 & 4	5	6
Subjects	N	Appropriate Response	Yes Response	Appropriate Activity	Own Words Easier	Justification
Six-Year-Olds						
Normal Kindergarten[b]	20	.05	.50	.20	.55	.10
Naive Educable	21	.00	.90	.00	.76	.00
Experienced Educable	40	.05	.95	.05	.82	.08
Eight-Year-Olds						
Normal Third Grade[b]	20	.55	.75	.70	.90	.75
Naive Educable	28	.21	.82	.18	.64	.28
Experienced Educable	30	.20	.83	.30	.73	.20

[a] Interrater reliability .96

[b] Normal data from Kreutzer et al. (1975)

Table 5

Classification of Student-Produced Lists for Recall

Classification		Taxonomic	Thematic	Rhymes Sound-alikes	Random
Group	N				
Normal:					
CA = 6	20	.21	.37	.14	.28
CA = 8	20	.72	.26	.01	.01
CA = 10	20	.68	.30	.00	.02
Educable:					
MA = 6	27	.38	.27	.10	.29
MA = 8	31	.42	.23	.12	.23

Table 6

Proportion of Categorical Responses Classified As Broad and Narrow

Classification		Broad	Narrow		
Group	N		Narrow	Narrow Superordinate	Total
Normal:					
CA = 6	20	.62	.32	.06	.38
CA = 8	20	.25	.64	.11	.75
CA = 10	20	.18	.57	.24	.81
Educable:					
MA = 6	27	.67	.26	.07	.33
MA = 8	31	.49	.37	.14	.51

Table 7

A Comparison of the Mean Importance Ratings of the Four Experimental Groups on the Prejudged Levels of Importance

(from Brown & Smiley, 1977a)

Importance Level	1 (least)	2	3	4 (most)
Third Grade	2.41	2.52	2.51	2.56
Fifth Grade	2.42	2.35	2.46	2.76
Seventh Grade	2.02	2.36	2.58	3.05
College Students	1.61	2.09	2.78	3.52
Total	2.12	2.33	2.58	2.97

Mean Proportion Correct Recall as a Function of Age and Structural Importance

Rated Importance	1 (least)	2	3	4 (most)	Total
Third Grade	.17	.22	.38	.61	.35
Fifth Grade	.23	.32	.48	.68	.43
Seventh Grade	.28	.39	.51	.75	.47
College Students	.27	.39	.54	.74	.48
Total	.23	.33	.48	.69	

Table 8

The Study Time Items from Kreutzer et al. (1975)

(Proportion of Subjects Selecting 1 or 5 Minutes)[a]

Subjects	N	Remembered Most 5 min.	Remembered Most 1 min.	Adequate Justific.	Subject's Choice 5 min.	Subject's Choice 1 min.
Six-Year-Olds (MA)						
Normal Kindergarten[b]	20	.75	.25	.35	.65	.35
Naive Educable	21	.81	.14	.29	.71	.29
Experienced Educable	40	.85	.15	.56	.69	.31
Eight-Year-Olds (MA)						
Normal Third Grade[b]	20	1.00	.00	1.00	.95	.05
Naive Educable	28	.86	.14	.57	.93	.07
Experienced Educable	30	.93	.07	.70	.93	.07

[a] Interrater reliability .99

[b] The data for normal children are from Kreutzer et al. (1975)

Table 9

Proportion Predicting Which Activity Will Lead to Best Performance (from Brown, Campione, Barclay, Lawton, & Jones, work in progress)

Activity	Categorize	Rehearse	Label	Look
Preschool (CA 4)	.24	.33	.13	.28
First Grade	.44	.25	.09	.22
Third Grade	.35	.46	.19	.00
Educable MA 6	.64	.36	.00	.00
Educable MA 8	.38	.62	.00	.00

Table 10

Proportion Predicting Categorize or Rehearsal Superior and Adopting that Activity (from Brown, Campione, Barclay, Lawton, & Jones work in progress)

Subjects	N	Predict Superior	Perform	P(Perform/Predict)
Preschool (CA 4)	46	.58	.13	.22
First Grade	32	.69	.25	.36
Third Grade	26	.81	.62	.77
Educable MA 6	14	1.00	.36	.36
Educable MA 8	21	1.00	.19	.19

P(Perform/Predict) = probability that the subject will perform the activity he predicted is the most suitable.

Table 11

Immediate-Delayed Item from Kreutzer et al. (1975)[a]

Response	N	Phone First or Aware	Activity to Remember			
Subjects			Write Down	Rehearse	Other	None
Six-Year-Olds (MA 6)						
Normal Kindergarten[b]	20	.40	.55	.00	.05	.40
Naive Educable	21	.65	.30	.00	.00	.70
Experienced Educable	40	.46	.46	.00	.00	.54
Eight-Year-Olds (MA 8)						
Normal Third Grade[b]	20	.95	.80	.10	.10	.00
Naive Educable	28	.75	.96	.00	.04	.00
Experienced Educable	30	.67	.63	.00	.03	.23

[a] Interrater reliability .93

[b] Normal data from Kreutzer et al. (1975)

Table 12

The Study-Plan Item from Kreutzer et al. (1975)[a]

Subjects	N	Planning a Strategy	Not Planning a Strategy
Six-Year-Olds (MA)			
Normal Kindergarten[b]	20	.45	.55
Naive Educable	21	.24	.76
Experienced Educable	40	.21	.80
Eight-Year-Olds			
Normal Third Grade[b]	20	.90	.10
Naive Educable	28	.25	.75
Experienced Educable	30	.20	.80

[a] Interrater reliability .93

[b] Normal data from Kreutzer et al. (1975)

Table 13

Proportion Correct on Recall-Readiness Posttests

			Posttests						
Group	Condition	N[a]	Original Data			One Year Follow Up			
			Prompt	No Prompt	No Prompt	No Prompt	No Prompt	Prompt	No Prompt
MA 6	Anticipation	8	.82	.62	.52	.50	.48	.81	.57
	Rehearsal	7	.77	.61	.49	.46	.50	.90	.63
	Label	6	.60	.56	.55	.46	.58	.78	.54
MA 8	Anticipation	12	.92	.84	.81	.80	.72	.95	.85
	Rehearsal	12	.89	.82	.81	.74	.73	.84	.83
	Label	11	.74	.65	.63	.60	.61	.67	.63

[a] Included are data from those children who were available for all phases of the experiment

Table 14

Mean Proportion Recalled in Training as

a Function of Age, Groups, Trial Blocks and Trials

(from Brown & Campione, 1977a)

Trial Blocks[a]

Age	Old		Young	
Trial Block	1	2	1	2
Groups				
Creeping	.46	.44	.36	.46
Standard	.50	.59	.34	.33
Random	.41	.42	.29	.28

Trials[b]

	Old			Young		
Trial	1	2	3	1	2	3
Conditions						
Creeping	.41	.43	.51	.34	.40	.48
Standard	.46	.55	.62	.32	.33	.35
Random	.41	.40	.43	.27	.28	.31

[a] The children received four lists a day. These were collapsed into two Trial Blocks.

[b] For each list the subject attempted four recalls, the last three following item selection. These are the Trials.

Table 15

Number Generalization Test, Random Lists

(from Brown, Campione, & Murphy, 1977)

	Originally Realistic		Originally Unrealistic No Feedback		Feedback	
	Young	Old	Young	Old	Young	Old
N	6	12	11	14	12	12
Mean Difference Score	2.83*	1.08	5.09	3.64	5.00	4.42
Proportion Realistic	.67	.75	.09	.28	.08	.25
Proportion 10 guessers	.17	.17	.73	.43	.67	.50

*This figure is misleading. There are only 6 subjects in this cell, 4 realistic and 2 unrealistic. The mean difference score for the 4 realistic subjects was 1.75. Both the remaining subjects overestimated their span by 5.

Table 16

Easier to Recall Judgments on the Number Generalization Problem*

(from Brown, Campione, & Murphy, 1977)

	Originally Realistic		Trained Realistic		Unrealistic	
	Young	Old	Young	Old	Young	Old
Organized Easier	.66	.75	.14	.26	.19	.12
Unorganized Easier	.00	.00	.14	.11	.13	.12
Inconsistent	.33	.25	.71	.63	.67	.75

*Entries are the proportion of subjects falling into each category

Figure Captions

Figure 1. The probability of a correct recognition given a wager of 1, 2, or 3 tokens in Experiment 1, or given a judgment of yes, maybe, or no in Experiment 2 (from Brown & Lawton, 1977).

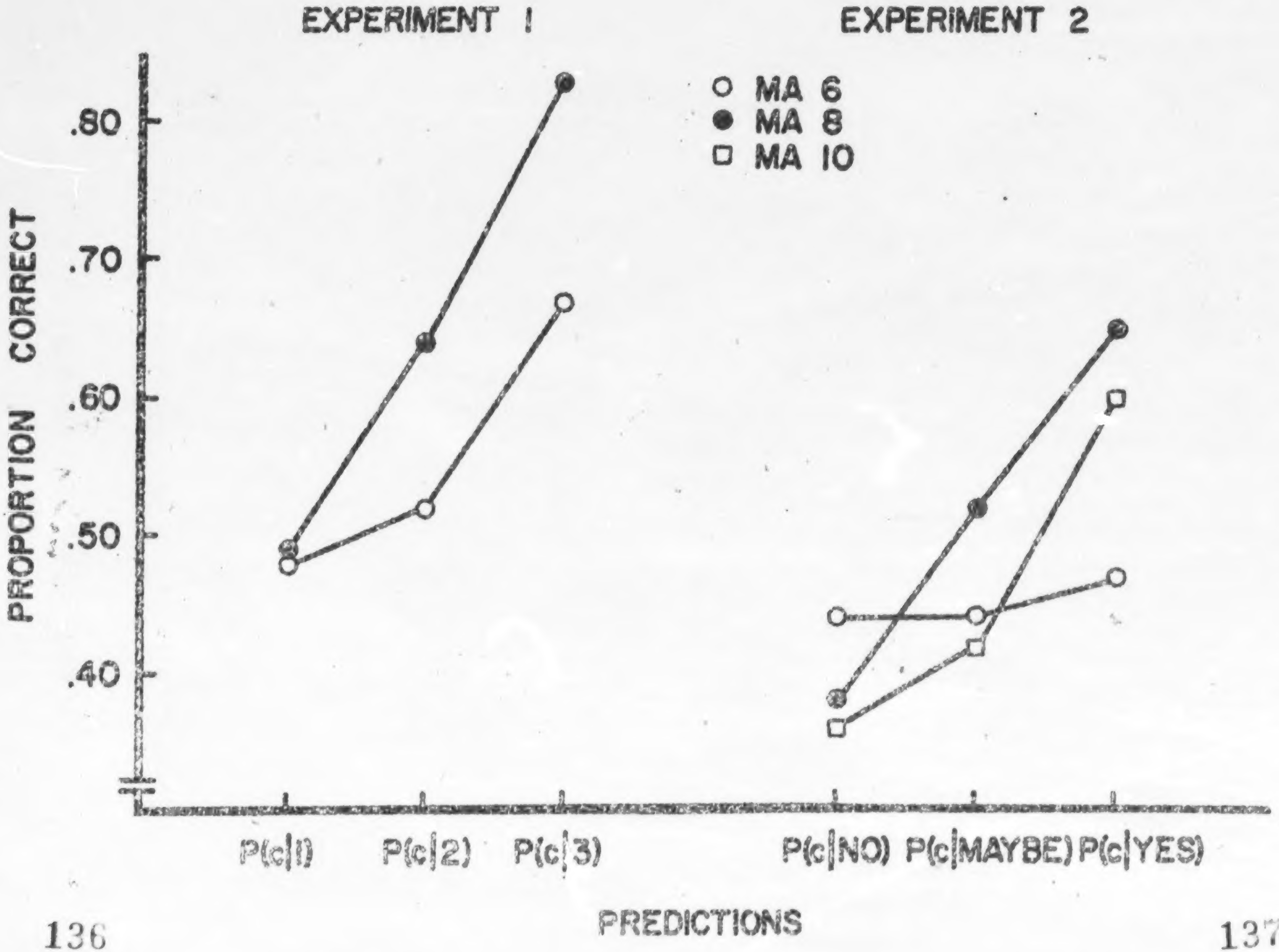
Figure 2. Proportion of correct recall as a function of mental age, training condition, and test phase (from Campione & Brown, 1977, adapted from Brown & Barclay, 1976).

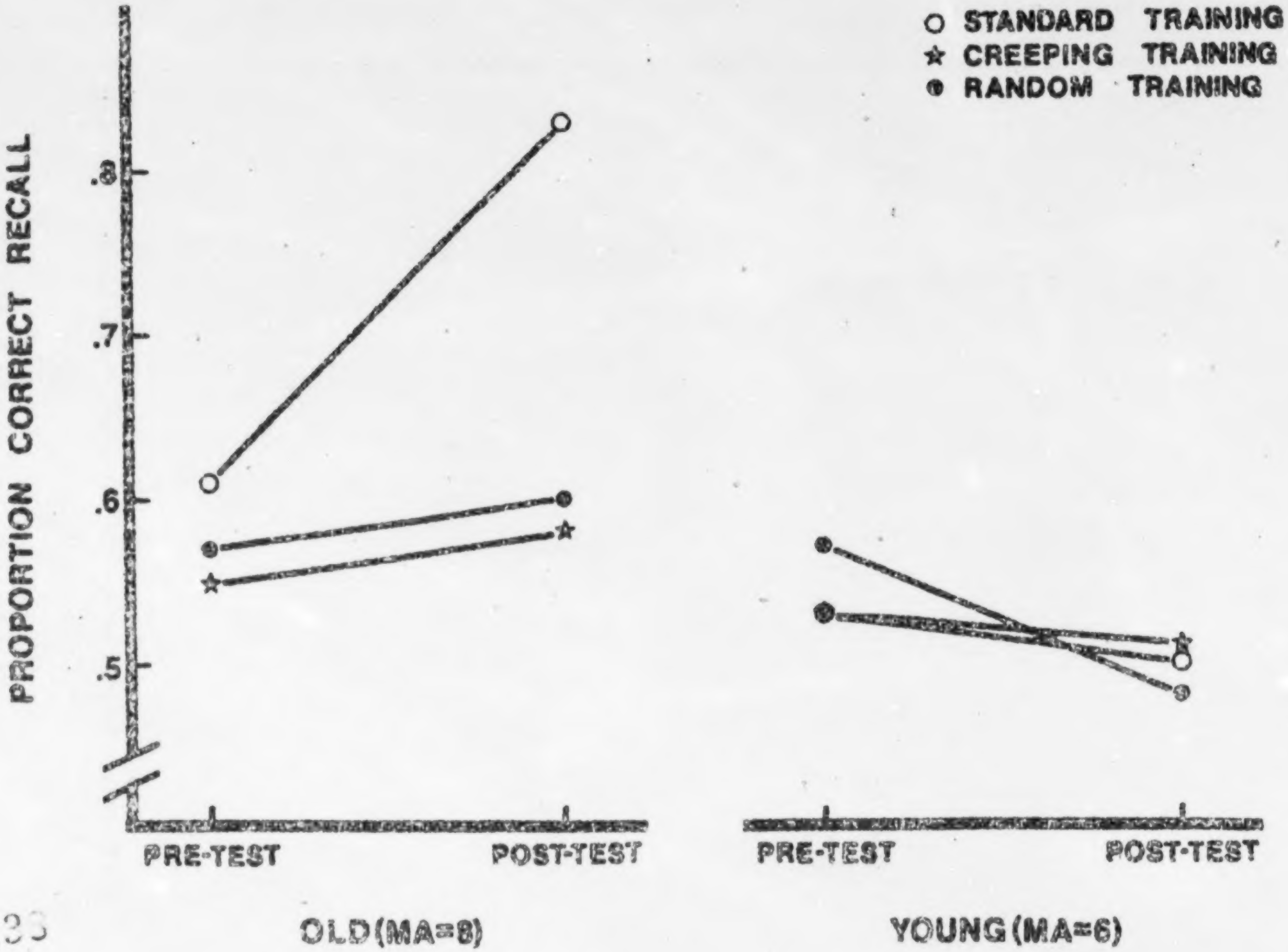
Figure 3. Mean proportion correct recall on pre and posttests as a function of age and training condition (from Brown & Campione, 1977a).

Figure 4. Mean standardized strategic selection scores on pre and posttests as a function of age and training condition (from Brown & Campione, 1977a).

Figure 5. The proportion of realistic estimators as a function of mental age and test phase (from Brown, Campione, & Murphy, 1977).

Figure 6. The proportion of realistic estimators (considering only those who were originally unrealistic) as a function of mental age, feedback condition, and test phase (from Brown, Campione, & Murphy, 1977).


EXPERIMENT 1
EXPERIMENT 2
○ MA 6
● MA 8
□ MA 10
PROPORTION CORRECT
.80
.70
.60
.50
.40
P(c|1)
P(c|2)
P(c|3)
P(c|NO)
P(c|MAYBE)
P(c|YES)
PREDICTIONS


○ STANDARD TRAINING
☆ CREEPING TRAINING
● RANDOM TRAINING
PROPORTION CORRECT RECALL
.8
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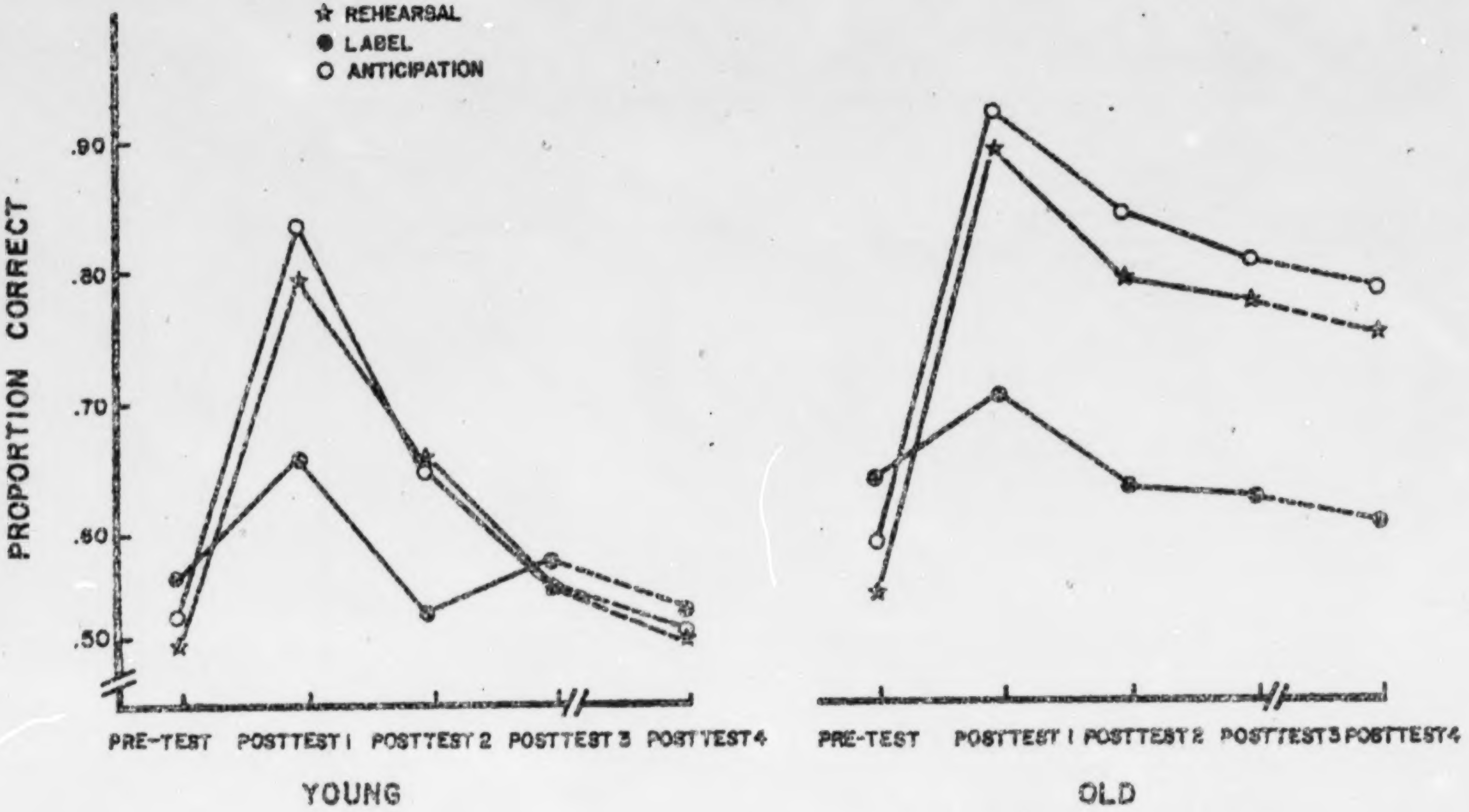
.6
.5
PRE-TEST
POST-TEST
PRE-TEST
POST-TEST
OLD(MA=8)
YOUNG(MA=6)


☆ REHEARSAL
● LABEL
○ ANTICIPATION
PROPORTION CORRECT
.90
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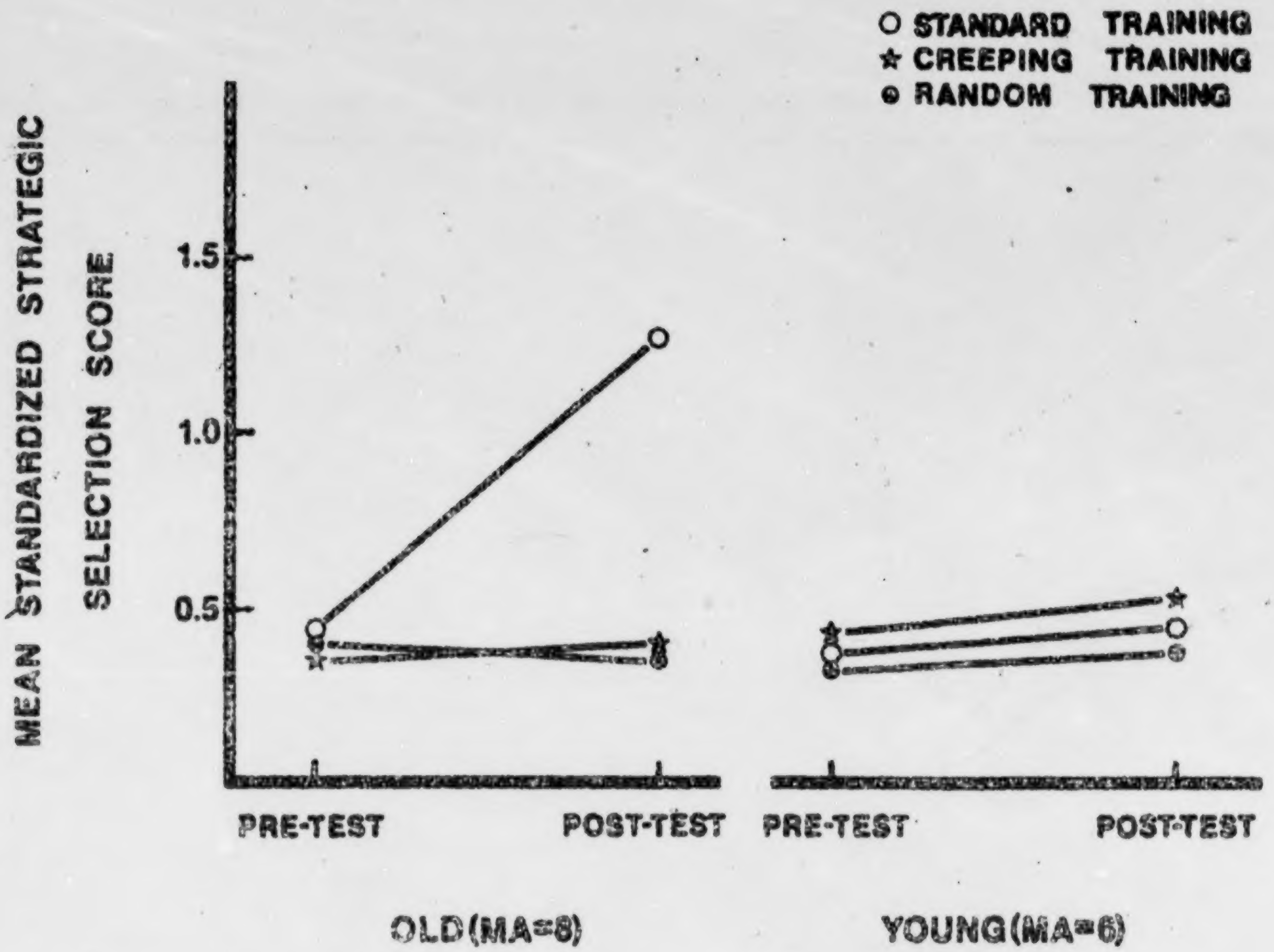
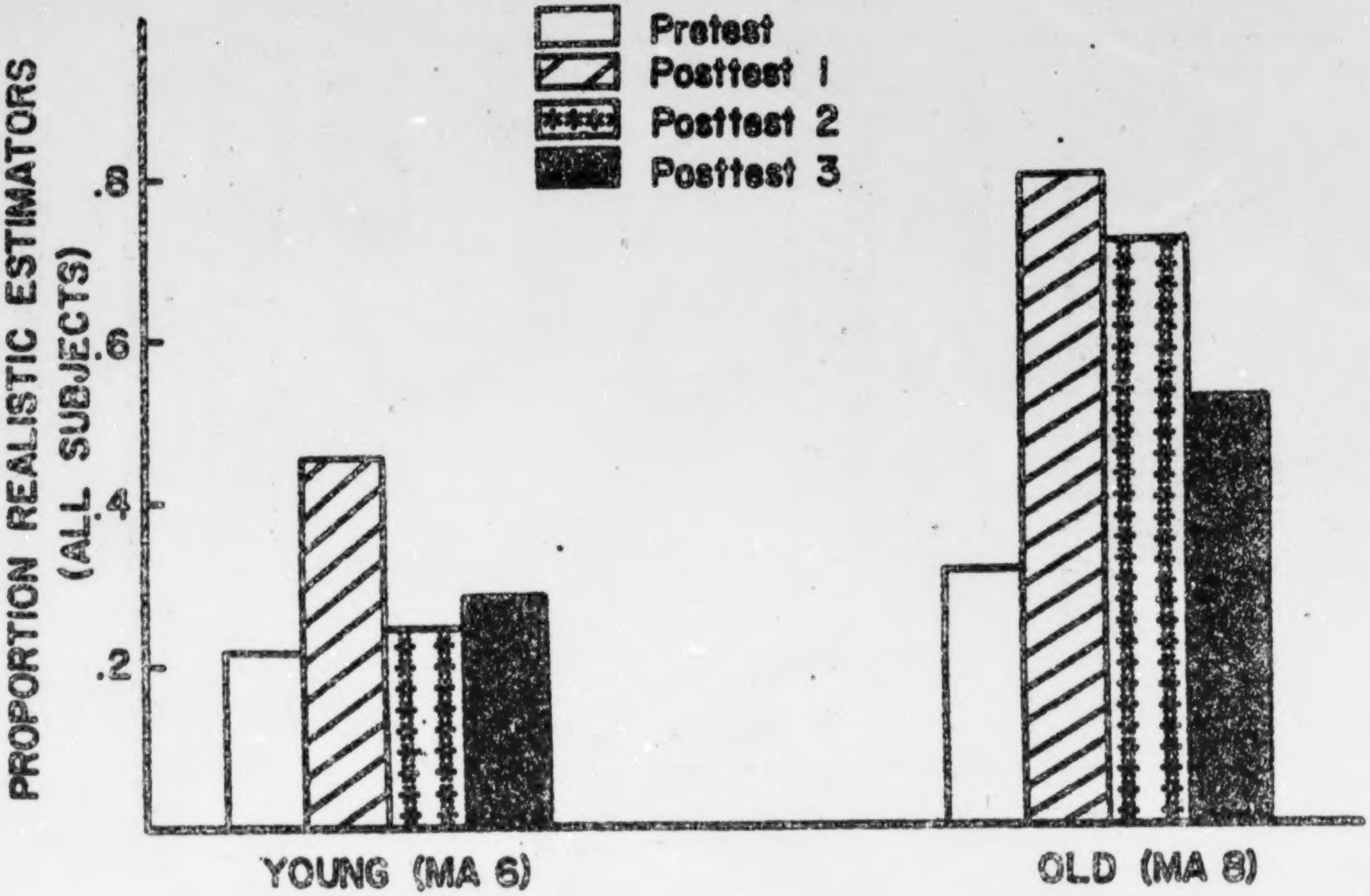
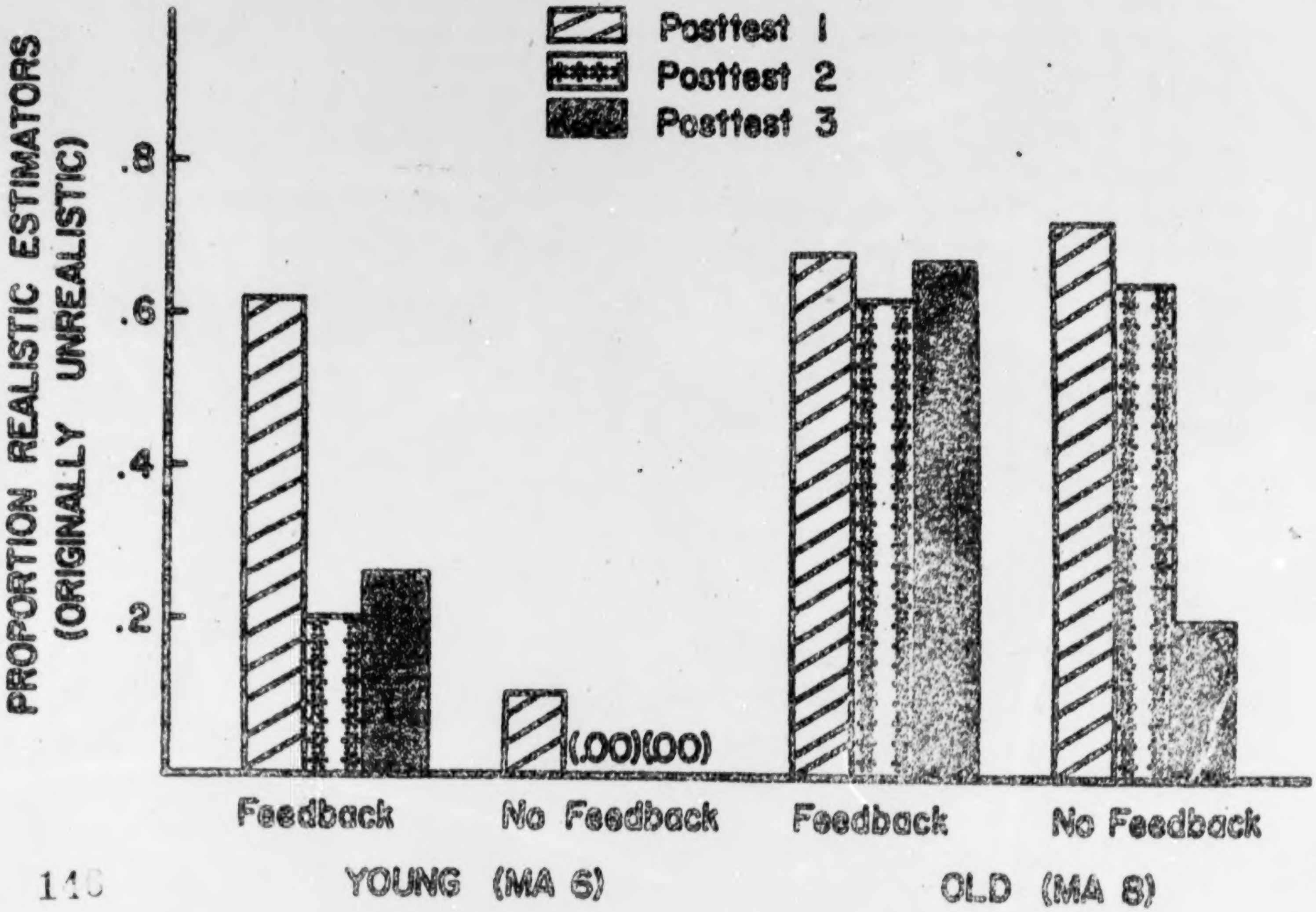
PRE-TEST
POSTTEST 1
POSTTEST 2
POSTTEST 3
POSTTEST 4
YOUNG
PRE-TEST
POSTTEST 1
POSTTEST 2
POSTTEST 3
POSTTEST 4
OLD



○ STANDARD TRAINING
☆ CREEPING TRAINING
⊛ RANDOM TRAINING
MEAN STANDARDIZED STRATEGIC SELECTION SCORE
1.5
1.0
0.5
PRE-TEST
POST-TEST
PRE-TEST
POST-TEST
OLD(MA=8)
YOUNG(MA=6)


Pretest
Posttest 1
Posttest 2
Posttest 3
PROPORTION REALISTIC ESTIMATORS (ALL SUBJECTS)
.8
.6
.4
.2
YOUNG (MA 6)
OLD (MA 8)


▨ Posttest 1
▦ Posttest 2
▩ Posttest 3
PROPORTION REALISTIC ESTIMATORS
(ORIGINALLY UNREALISTIC)
.8
.6
.4
.2
(.00)(.00)
Feedback
No Feedback
Feedback
No Feedback
YOUNG (MA 6)
OLD (MA 8)

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